THE VEGETATION OF SOUTH FLORIDA SOUTH OF 27 30 NORTH, EXCLUSIVE OF THE FLORIDA KEYS

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SOUTH OF 27° 30′ NORTH, EXCLUSIVE OF THE FLORIDA KEYS

BY

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THE VEGETATION OF SOUTH FLORIDA

EXCLUSIVE OF THE KEYS

SOUTH FLORIDA may be said to comprise that part of the State south of 27° 30′ north latitude, including the Florida keys. It represents the extreme subtropic portion of the peninsula, and is a region of very diverse character. It includes Lake Okeechobee, the Everglades and contiguous land masses within its confines. It is a country of low relief. In some places it is perfectly flat, in other places slightly rolling. There are no two maps of the region that agree in all essential geographic details. There are many districts south of Lake Okeechobee that are *terra incognita* to the scientific geographer. The coast line is irregular and in many places protected by islands, or keys, and mangrove swamps. It is approximately 257.44 km. (160 miles) from the northern parallel, 27° 30′, to the extreme southern end of the peninsula, excluding the Florida keys, which will be considered only incidentally in the following pages. The region is 235.26 km. (140 miles) from east to west. Geographically it includes the whole of Manatee, De Soto, Lee, Palm Beach, and Dade counties and parts of Osceola, St. Lucie and Monroe counties. The eastern coast is bathed by the Gulf Stream, which for two degrees of latitude, between 25° and 27° N., is contracted to a narrow strait between the Great Bahama Bank and southern peninsular Florida. The axis of the Gulf Stream is not over 41 kilometers (25 miles) off-shore in the middle of the Strait of Florida, which is not over 80 km. (50 miles) wide in its narrowest portions. Consequently, the shore line of the eastern part of Florida along the Florida Strait is steep, the 100-fathom curve being only about three miles off-shore, while the 20-fathom curve is about 1.6 km. (1 mile) off-shore at Ft. Lauderdale, where the slope is the steepest.

Indian River Inlet, which connects Indian River with the Atlantic Ocean, is almost exactly at 27° 30′ north latitude. Starting with that inlet, we find the Florida mainland protected, or fringed, by a series of barrier beaches separated from the peninsular land mass by elongated bays or lagoons. In fact, these islands, or bars, are merely the continuation of those along the coast, as far north as Long Island, New York. Along the At-

lantic coast from Cape Hatteras southward, there is a southward-setting current,* which makes a gradual drift of silicious sand all the way down to Cape Florida. Hence it comes about that the sands fill in on the northern side of the inlet, and force the exit waters continually to widen the opening on their south banks, a process which causes the inlets to move down the coast. South of Cape Florida, Soldier Key begins the chain of Florida keys, where the coral beaches of calcareous sand take the place of the silicious sand beaches that extend north to Cape Cod. High dunes are characteristic of that part of Florida about Jupiter Inlet, where the wind-blown sand is silicious. Low dunes, or none at all, are characteristic of the coral beaches, because the calcareous sand lends itself to rapid solution by rain water and later the grains may become rapidly consolidated into a tolerably firm mass, or rock.

These coastal islands are separated by a number of inlets, which, beginning with Indian River Inlet, are from north to south St. Lucie Inlet, Jupiter Inlet, Lake Worth Inlet, Hillsboro Inlet, Ft. Lauderdale Inlet. South of Cape Florida, where the coral beaches of the keys are found, the passageways between the several islands are not designated on the coast map, but the keys which concern this phytogeographic study are from north to south Virginia Key, Key Biscayne, Soldier Key, Ragged keys, Sand Key, Elliott Key, Old Rhodes Key, and Key Largo.

The keys, which are considered only incidentally in this monograph, are divided into four groups: The first group, called by Small† the Upper Sand keys, comprise Virginia Key and Key Biscayne, of silicious sand. The second group, or Upper keys, consist of the keys that extend from Soldier Key to the West Summerland, or Spanish Harbor keys. They consist fundamentally of Key Largo limestone, and in the higher keys, dense hammocks are found. They are of younger coral rock than the Lower keys, which consist fundamentally of Miami-Key West oölite, which forms the basic rock of the ancient Miami keys, which are a part of the mainland. The fourth group of the Lower Sand keys are composed of sand. They extend from the westward of Key West out into the Gulf of Mexico, and their vegetation has been investigated by Millspaugh.‡

* Cf. *Shaler, N. S.:* Beaches and Tidal Marshes of the Atlantic Coast. Physiographic Processes, 1 : 153.

† *Small, John K.:* Flora of the Florida Keys, p. iii.

‡ *Millspaugh, Charles F.:* Flora of the Sand Keys of Florida. Botanical Series, Field Columbian Museum, ii, No. 5, Feb., 1907.

Inside of the barrier beaches and between them and the mainland are shallow lagoons, or bays, which are gradually filled with sand blown over the beaches, or by accumulations of organic material derived from salt marsh vegetation, or from that collected by the roots of the red-mangrove, which in some places is an important agent in land building. In Florida, these lagoons are designated rivers if they are narrow and long, or lakes, bays, or sounds, if they are short and broad. The geographic sequence of such lagoons along the east coast of Florida south of 27° 30′ north latitude is as follows: Indian River (St. Lucie Sound), Jupiter River, Lake Worth, Boca Ratonas Lagoon, Hillsboro River, New River Sound, Dumfoundling Bay, Biscayne Bay, Cards Sound, Barnes Sound. A number of important, but short, rivers that take their rise in the Everglades flow east and empty into these land-locked sounds. They are, proceeding from north to south: St. Lucie River, Jupiter River, Hillsboro River, Cypress Creek, New River (with its several branches), Snake Creek, Arch Creek, Little River, Miami River, Snapper Creek, Black Pool Creek, and Chis Cut.

The high ground of the east coast of Florida is a narrow strip between the ocean and the Everglades. This region is formed of Palm Beach limestone, a light-colored, hard to friable limestone extending from St. Lucie River south to Delray and covered near the coast with loose wind-blown sand that rises into hills of considerable height. From Delray south to Homestead, and including the Everglade keys west of that place, the underlying rock is Miami limestone, while a tongue of Pleistocene and Recent sand extends along Jupiter River, Lake Worth and along shore to the Hillsboro River. The country between Lake Okeechobee and the coast, as indicated on the map, is one characterized by numerous small lakes of fresh water that have no outlet and that are not connected with each other. This geographic region will be discussed more fully under the heading of geology.

Lake Okeechobee is an irregular body of fresh water, about 36 miles long from north to south and about 30 miles wide from east to west and ranges in depth from about four to twenty feet.* A number of wooded islands are found at the south end of the lake. These have been named Observation, Rita, Kreamer and Torry islands. A number of streams empty into the lake. The principal are Taylor Creek, Kissimmee River, and Fisheating Creek. The

* *Heilprin, Angelo:* Explorations on the West Coast of Florida and in the Okeechobee Wilderness. Transactions Wagner Free Institute of Science, Vol. 1, Philadelphia, 1887.

Kissimmee River drains Lake Kissimmee, Lake Istokpoga and several other large lakes in the lake district of central Florida, so that perhaps over one-third of the state is finally drained into Lake Okeechobee and through the Three Mile Canal into the Caloosahatchee River, the main outlet of the lake waters to the sea. Up to date, the water level of the lake is lowered through the North New River Canal into New River, and the South New River and Miami Canal into Miami River. The Hillsboro Canal lacks only 3 kms. (2.1 miles) of being cut through to tidewater. The excavation of the South New River Canal, connecting the Miami Canal with New River, is completed. Considerable water must find its way underground into the Everglades.

The vast area of country known as the Everglades is a depression filled with saw-grass interspersed with channels and lagoons. The eastern limit of this region is the elevated ridge of the Palm Beach and Miami limestone, while its western boundary is the vast prairies, pinelands and cypress swamps. The southern extremity extends to the Gulf, but here are found the Everglade keys of more elevated limestone rock. The drainage of the Everglades is by the short rivers previously mentioned that empty into the Atlantic Ocean. Part of the surplus water of the 'Glades finds its way into the Gulf of Mexico through the Caloosahatchee River, which is a meandering stream deep enough to float fair-sized steamers that ply its swift, but placid waters. The southwestern portion of the Everglades drains into the Gulf of Mexico by several short rivers, such as the Harney, Rodgers, Lostmans, Shark and Chatham rivers, but the drainage in this direction must be much more sluggish than through the eastern streams that empty into the Atlantic Ocean. The country northwest of Lake Okeechobee and north of the Caloosahatchee River is characterized by a large number of small lakes, by pineland, by prairie, by salt marshes and by several large rivers such as the Miakka, Peace Creek and its tributaries. South of the Caloosahatchee River, there are pineland, hammocks, cypress swamps, lakes, sloughs and prairie glades.

The western coast of southern peninsular Florida down to Cape Romano is a series of islands, or barrier beaches. Beginning at Sarasota Bay, we first encounter Long Key, Casey Key, Little Gasparilla Island, Gasparilla Key, Lacosta Island, Captiva Island, Sanibel Island, Estero Island, and several other unnamed islands represented on the most detailed maps of the region. The lagoons which are found between these keys and the mainland are Sarasota Bay, Little Sarasota Bay, Lemon Bay, Gasparilla Sound,

Charlotte Harbor, Pine Sound, San Carlos Bay (at the mouth of the Caloosahatchee River), Estero Bay, and a number of the smaller lagoons. Parts of the mainland, as at Naples and at Horse Point and Chaise Point, are washed by waves of the Gulf of Mexico. South of Cape Romano, the shore line is deeply embayed. Here we find the coast an intricate maze of flats covered with red-mangrove thickets which are intersected with tortuous channels of shallow water. This type of shore line continues to Cape Sable, where sandy deposits take the place of the mud flats. This short geographic description of South Florida will serve as a statement of the position of the most salient features upon the map.

PHYSIOGRAPHY

It remains, however, to give a few facts in line with modern physiographic study. The coast of South Florida is characterized to a great extent by growing coral reefs, which extend along the coast for over 200 miles and are found nowhere else in the continental limits of the United States. The South Florida mainland has all the aspects of infancy. Drainage is sluggish, lakes, shallow ponds, and sloughs are common. The interior is a marsh and the river systems and stream valleys are not well defined. The short rivers that flow from the Everglades into the Atlantic Ocean are characterized by rapids where they flow from the 'Glades. This aspect of infancy is due, according to Sanford,* to two operative causes, one the actual recent deposition of the beds, consolidated and unconsolidated, and the other, the slight elevation of the deposits above tide level since deposition. The rocks have had relatively little time to suffer erosion, and this erosion has been delayed because the surface has been too flat to allow clear streams, sediment free, an opportunity to erode valleys and establish well-marked drainage systems. The present Florida mainland, as shown by Dall and others, is the top of a great submarine plateau, the eastern edge of which is near the present shore line, but the western edge extends many kilometers gulfward. The slope of the southern land mass is due to the reaction, or play, of forces between land and water, so that it is inconstant. The shore line topography has a varied look. Its form in places is that of infancy; in other places, of youth, or adolescence. Here and there are found cuspate forelands (projecting capes), fringing sand

* *Sanford, Samuel:* The Topography and Geology of Southern Florida. Second Annual Report, Fla. Geol. Surv., 1909: 179.

islands, and coral reefs with inlets, lagoons, and reëntrant bays. In other places, the smooth shore line has long sweeps and easy curves.*

Although the surface of South Florida shows slight relief, the average elevation not over 6 m. (20 feet), its general slope is south, with a slight tilt to the west, as is demonstrated in a study of the drainage of water from Lake Okeechobee and the Everglades. A depression of 15 m. (50 feet) would entirely submerge this portion of the State and an elevation of 15 km. would make dry land of the bottom of the Bay of Florida, and Biscayne Bay and would extend the coast line 60 km. (forty miles) west of the entrance to Shark River and twenty miles to the west of Cape Romano. During the Pleistocene and recent history of southern Florida, there have been no great disturbances marked by elevations or depressions of the land surface, although slight oscillations of the surface in an up and down direction are indicated. The forces at work have been those concerned with the growth of coral reefs, their wasting away, the movement of sand, the formation of bars and the filling of shallow bays by sedimentation largely consequent upon the growth of mangrove trees, and through the agency of other vegetation in open lakes and swamps.

GEOLOGY

The logs of deeply driven wells in South Florida show that deposits of the Oligocene, the Miocene, and the Pliocene ages are buried beneath superficial strata, which alone concern us in this account, because the upper exposed strata alone are influential in the formation of soil in which plants grow. The deposits of Pleistocene age exposed to the action of the elements comprise limestones, coquina and sands. The limestones are found in the form of bare ridges, or scattered outcrops, while the coquina lies along, or back of, the east coast line, and the sands cover the surface of the greater part of the southern portion of peninsula. The superficial limestones are classified as Palm Beach limestone, Miami-Key West oölite, Key Largo limestone, and Lostmans River limestone.

The Palm Beach limestone is a non-oölitic marine limestone found as inconspicuous outcrops scattered sparsely through the pineland, cypress swamps, and prairies along the eastern side of the Everglades from Delray

* *Gulliver, F. P.:* Shoreline Topography. Proc. Amer. Acad. Arts and Sciences, xxxiv, No. 8, 1899.

northward. These outcrops, although scattered, probably extend northward into St. Lucie County, as depicted on the geologic map published in the Second Annual Report of the State Geologist of Florida. These limestones are covered by the sand dunes of the east coast, by the sands and peat of the Everglades, and in thickness vary from 1.52 m. (five feet) to 15.24 m. (50 feet). For a distance of 48 km. (30 miles) these limestone deposits help to define the eastern rim of the Everglades.

The geologic map of Florida, published in the second report of the State Geological Survey (199), shows that the area immediately south of the sand hills at Delray, as far south as Cards Sound along the east coast, is characterized by outcrops of oölitic limestone designated as Miami-Key West oölite. The exposures were noted by army officers at the time of the Seminole war, by Tuomey, L. Agassiz, Shaler, A. Agassiz, and others. Buckingham Smith, as early as 1847, found many mollusk shells in the oölite at Miami River and determined the age of this deposit as post-Pliocene. The rock is perhaps younger than the Palm Beach limestone and is younger than the lower part of the Key Largo limestone. The thickness of the Miami-Key West oölite varies, according to the studies made in the drilling of wells. At Ft. Lauderdale it is four meters thick, at Dania 12 meters, at Miami 6 meters. These figures, making due allowance for the scantiness of the data and the unreliability of the well records, unless accompanied by samples, show that the maximum thickness may be 16 meters along the coastal outcrops and perhaps more inland. At Miami, the oölite rests on an irregularly cemented aggregate of shell fragments and quartz sand. It rests on "blue sand" at Dania and on sand at Ft. Lauderdale. Lithologically the rock is a soft, white oölitic limestone, containing thin irregular layers of calcite separating less crystalline streaks, and is discolored by weathering, by the deposit of vegetal mould and the growth of lichens, mosses, and algæ. It breaks with an irregular fracture, dresses nicely, hardens on exposure, and makes a good road and building stone. This oölite carries a varying proportion of small, irregular grains of quartz sand, which are more plentiful in the northern part of the area covered by Miami-Key West oölite. The Miami-Key West limestone, which extends to the edge of the Everglades and perhaps beyond, weathers into sharp angular fragments, which lie loosely on the surface, or it is eaten into pockets often filled with sand. The surface, therefore, is very rough and uneven,

and owing to the honeycombed character of the rock, which is in some places full of larger and smaller pot holes.

The limestone country is one of little relief. The maximum elevation of the ledges south of Miami may be ten meters (30 feet) above sea level, but the rise is so gradual as to be almost imperceptible. The maximum elevation on Long Key in the Everglades, and at New River, is about two and a half meters (eight feet).

West of the Bahia Honda Passage and comprising an extreme western series of islands (see previous classification of keys) are a number of keys characterized by a limestone rock known to the Florida geologists as Key West oölite, which is a soft, white, or light-colored, fossiliferous oölitic limestone, less sandy than the Miami oölite. Such keys as Big Pine, Little Pine, Cudjoe and Key West belong to the western series of keys, where the oölitic limestone prevails. The Miami and Key West oölites differ so slightly that they may be assumed to have had a common origin. A study of the vegetation found on these oölitic limestones bears out their common character and I, therefore, propose for oölite of common origin, and perhaps age, the name Miami-Key West oölite. Outcrops of the Miami-Key West oölite are not known north of Delray, nor anywhere on the west coast. Exposures of it occur in bluffs near Miami and in low ridges a few miles west of that town. However, much of the Miami-Key West oölite is flat-topped, and this is true also of the smooth exposures in the keys west of Bahia Honda. From the evidence of plant distribution, the writer believes that the outcrops of Miami-Key West oölite were elevated sooner above the surface than the Key Largo limestone, which forms the material out of which the connecting chain of keys is composed, for it has been recognized that the elevated reef that forms the backbone of the main series of islands from Bahia Honda to Soldier Key consists of coralline material.

The Key Largo limestone represents the only known fossil coral reef in southern Florida, and lithologically, it is differentiated sharply from any of the other limestone of the mainland and keys. In all probability, it was built up from a depth of 30 km. (100 feet). The Key Largo limestone may be in part contemporaneous with the Miami-Key West oölite which is believed to represent shallow water deposits formed behind the coral reef and finally extended over it, for in places the Miami-Key West oölite rests on the Key

Largo limestone formed from the ancient coral reef. The writer believes that the evidence of the vegetation is sufficient to prove that, although contemporaneous, or even earlier, in formation than the Miami-Key West oölitic deposits, the Key Largo limestone was elevated later above the surface of the sea, thus forming a land bridge between the disconnected areas of Miami-Key West on the mainland and in the extreme western groups of keys. The evidence for this view will be presented subsequently.

Lostmans River limestone is a non-oölitic fossiliferous one, which apparently underlies the western coast of southern Florida with outcrops exposed inland. These limestones underlie the gray sands of the mainland, the marls of the coastal swamps, the islands of the southern portion of the Ten Thousand islands, and extend along the southwestern border of the Everglades. The stratigraphic position of this limestone has not been determined with exactness. Sanford* thinks that the Miami-Key West oölite is younger than the non-oölitic limestones which lie between its north and south divisions, and the fact that in general the west coast of Florida is older than the east coast and the facts of plant distribution lend support to this view.

There is a widespread covering of sands through the central part of the peninsula of Florida and these sands extend southward to Miami on the east coast and to Everglade on the west coast. These sands have probably been blown inland from the material carried southward along the eastern shore of North America by oceanic currents. At the surface, the sands are white or gray, below the surface they are of yellow, orange, and red hues. The deposits in southern Florida of recent age consist of peat, of marl, of sands, of coral reefs, and of oyster banks. The peat has been formed most extensively to a depth of one to two meters (about six feet) in the Everglades. The marls have been laid down on beaches, in swamps, and in lagoons and on the sea bottom, such as the limey oozes that cover wide expanses of the bottom of the Bay of Florida and elsewhere. The recent quartz sand deposits are those of the beaches and the wind-blown sand of the dunes. On the east coast these end with Key Biscayne, for the beach sands of Soldier Key and the series of islands extending to Key West are calcareous. The recent coral reefs are found off the arc of the Florida keys from Soldier Key to the Tortugas, and they are of the barrier type. The seaward slope is steep, but the living coral polyps carry on their work in water one and a half to 8 meters deep, where heads and

* *Sanford, Samuel:* Second Annual Report Florida Geological Survey, p. 219.

clumps of coral rise to the level of low tide. Banks of solidly packed oyster-shells make bars at the mouths of many of the rivers, as in the case of the Caloosahatchee River.

During Pleistocene age, there was a period of submarine upbuilding of quartz sands and calcareous material moved southward by oceanic currents. A depression of 30 meters (100 feet) occurred later, during which the beach and bar deposits grew in thickness on the east coast and the coral reef grew and spread southward of the mainland. Quartz sands, calcareous sands and muds accumulated in the shallow water off the west coast. Following this depression, according to Sanford,* there was a brief uplift of the land to possibly 60 meters (200 feet). Beach sands were driven inland and formed dunes. The coastal limestone was eroded by the sea and honeycombed by rain-water. Following the uplift came a depression which brought the land surface nearly to its present level. The Everglades in recent times have been formed in the southern part of a lake larger than the present Lake Okeechobee. Sands and muds, and other materials, were deposited along the shores of mainland and keys and have contributed materially to the formation of the present shore line.

The last element of the geology of South Florida, which concerns this general description, is the Caloosahatchee marl which represents Pliocene deposits, first discovered by Heilprin in 1887 and to which he gave the name Floridian. The Caloosahatchee marl is a light-gray shell-marl, often interbedded with nearly pure sand. It is usually very calcareous, but locally sand is abundant. The shells that enter into the formation of the marl are in a remarkable state of preservation and so easily identified. The thickness of the beds along the Caloosahatchee River is on the average about 2.4 meters (eight feet). Occupying a low level, the marl beds have been dissected by river action to only a slight extent. This marl includes all of the elevated land between Caloosa and Labelle, when with an eastward dip they are finally covered by deposits of Pleistocene age. Along this stretch of river, there are numerous exposures of the Caloosahatchee marl between Caloosa and Labelle, where they have a thickness of 1 meter, beneath 1 meter of fossiliferous Pleistocene marl covered by 1 meter of sandy loam.

Other localities are known along streams entering into Charlotte Harbor, where similar marl beds occur. Such are the Caloosahatchee beds

* *Sanford, Samuel:* Second Annual Report Florida State Geological Survey, 231.

along Alligator Creek, Miakka River, Rocky Creek, Peace Creek and Joshua Creek. The exact location of these deposits is given on the excellent geologic map of the state published in the Second Annual Report of the Florida State Geological Survey.

This general geologic account of the southern end of the Florida peninsula will serve to orientate us with respect to the time at which the existing land, soil and rock strata appeared. It will also enable us to connect the geographic character of the country with its geologic structure. The details that have been omitted in the general account will be emphasized when we discuss the plant formations and associations, as their geographic distribution is influenced by the edaphic conditions of the country.

PHYTOGEOGRAPHY

South Florida is a region of unusual phytogeographic interest. The climatic conditions are fairly uniform, so the environmental factors, which are considered as climatic, influence all plants much in the same way. The edaphic conditions, which include the character of the soil and the amount of water in the soil, are more important in the allocation of plants to certain habitats than are the climatic factors. South Florida is a country of little relief and its flat surface, although varying to some extent in altitude above sea level, shows change in level from place to place always as a gradual and sometimes imperceptible one. A few centimeters difference in level will bring about an entire change in the water-holding capacity of the soil, and, therefore, an entire change in the vegetation. The lines of demarcation between the different plant formations and associations are sometimes very sharply drawn. For example, a person can stand with one foot in the pine forest and the other in a prairie glade (Plate X, Fig. 2), indicating that the line of separation between hammock and pineland is in many places very distinct. The soil varies from locality to locality. Near Delray are extensive inland sandhills in the pure silicious sands of which certain associations of trees are found (Plate II, Fig. 2). The pineland of the area underlaid by the Miami-Key West oölitic limestone differs from that of the sandhills (Plate II, Fig. 3), while the vegetation of the Everglades is related to other marsh vegetation in North America.

The phytogeographer can distinguish a larger number of plant formations

and associations than can the systematist,* because he has been trained to working with vegetation units rather than with species and the habitats of species. The systematist usually emphasizes the peculiarities of land surface classified by the geographer, but the plant geographer and ecologist must insist on a classification based on the succession of vegetation; how the formations and associations are related to each other, and what their derivation has been from formations and associations that have preceded.

The characterization of any plant formation and association does not depend upon the enumeration of all the species that enter into association, as some systematists of rather narrow view would have us believe, but upon the forms which are dominant, which control, or which give physiognomonic expression to the type of vegetation studied. It is possible to describe a formation, or an association, by the mention of only one or two species without a complete list of all the species that are found growing together. This is an important principle and should be emphasized by plant geographers. It might even happen that the ecologist might describe a formation by mentioning correctly the dominant growth forms and their growth habits, and yet he might, in the enumeration of the secondary species, make mistakes in the identification of some of the plants. His conclusions would not be vitiated by such mistakes, because he has approached the study from the standpoint of the vegetation as a whole and not from the specific standpoint of the systematist. For example, the phytogeographer describes the character of a pine forest, the growth of the dominant pines, the formation of a crown and shade, the secondary species, their suppression in the forest, the herbaceous plants of the forest flora. His conclusions as to the character of the association of species may be perfectly correct scientifically and of great value, as giving a general view of the vegetation of a country, and yet, for the sake of argument, a number of his determinations may be open to question. Of course, accuracy in specific determinations is to be desired highly in all this kind of botanic investigation, but the point which it is desired to emphasize is that vegetation can be described without mentioning specifically a single plant.

An account will be given of the plant formations and associations, followed by a discussion of the probable derivation and successions of the various types of vegetation found at the southern end of the Florida peninsula.

* Of course, there are always exceptions.

SEA STRAND FORMATIONS

The sea beaches and the undulating surface back of them in South Florida consist of two kinds of materials, as previously indicated. Silicious sand is the material which forms the beaches and dunes of the coast north of Key Biscayne, while Soldier Key and the islands south of it have their sea beaches formed of calcareous sand, which represents the ground-up particles of coral, shells and calcareous seaweeds. The hills formed by wind-blown silicious sands may reach considerable elevation, while those of calcareous sand are usually low, because the particles, through the action of rain water, are often cemented together and are not blown about by the fickle winds.

Sea Beach Plant Formation.—The observations which follow are based on an examination of the beaches of silicious sand in South Florida. Little or no study was made of the flora of the calcareous beaches of the keys, the vegetation of which for the most part is excluded from this account. The sand which forms the beaches is a medium fine quartz sand and rather angular. Its color varies from gray, the prevailing tint, to pale yellow, to light reddish brown. We may distinguish three subdivisions of the beach, viz., the lower, or front, beach, the middle beach and the upper beach. The lower beach is without visible vegetation, as it is covered and uncovered by the rising and falling of the tides, and is exposed to the full force of the breakers, when the surf is at all rough. It slopes gradually seaward with a gentle declination, so that the bathing is usually safe. This is the submerged beach. The middle beach is characterized by the material that has been cast ashore by the higher tides. It is covered with a miscellaneous flotsam and jetsam, such as seaweeds, fruits, and seeds, driftwood, broken shells, animal remains, and the like. The lower part of the middle beach is without rooted plants, but if it is wide, we find its upper levels invaded by plants that are normally found as tenants of the upper beach, which stretches to the foot of the dunes. The middle beach and the upper beach sand is usually dry when the tide is out, but the lower beach sand shows the presence of a considerable amount of interstitial water which is demonstrated when the foot is pressed into sand which whitens, owing to the expulsion of water, while as soon as the foot is lifted the original gray color is restored. A study of the beach flora of subtropic Florida naturally resolves itself into an examination of the flora of the upper beach. Observations were made at five widely separated localities, viz., the beaches of Anastasia Island off St. Augustine, Ormond Beach, Ocean

Beach (Fairyland) opposite Miami, Punta Rassa at the mouth of the Caloosahatchee River, and Sanibel Island, across San Carlos Bay on the west coast. The vegetation of Anastasia Island, which is 283 kilometers (about 170 miles) north of the northern limits of South Florida is described by way of comparison.

The description that follows is based on notes made in the field, upon the published maps of the coast and upon the collection of plants made by the writer, marked by an asterisk, and by other botanists whose collections are found in the herbaria of the University of Pennsylvania and the New York Botanical Garden.

Beach Formation on Anastasia Island.—The beach of Anastasia Island, which is easily reached from St. Augustine by trolley, is locally called South Beach and is much frequented as a bathing beach. The beach is very wide and flat. The lower and middle beaches are devoid of vegetation. The middle beach, during my visit on December 25, 1910, was marked by aeolian sand ripples, which gave a billowed appearance to the surface. The sorting action of the wind was remarkably shown in that the heavier grains of sand formed the crest and the lighter grains the trough, showing that the winds were just sufficiently strong to lift the smaller grains and not strong enough to destroy the rippled surface.†

The upper beach was also rippled and was characterized by the long creeping stems of *Ipomœa pes-capræ (L.) Sweet, with open capsules out of which the large hairy seeds were falling to the sand beneath. Straggling bushes of *Croton punctatus Jacq. (=Croton maritimus Walt.) were noted. The sea rocket, *Cakile edentula (Bigel.) Hook., was also common on the beach.

Beach Formation of Ormond Beach.—The lower and middle beaches at Ormond form a level surface of sand which, on account of their unusual width, are used for automobile races. They are entirely destitute of flowering plants. The upper beach is terraced and is partly covered with *Uniola paniculata L., associated with Cakile edentula (Bigel.) Hook., *Ipomœa pes-capræ (L.) Sweet, and clumps of *Croton punctatus Jacq. Houstonia rotundifolia Michx. is a perennial, prostrate, creeping herb growing in the dunes and between the seaside-oats. Here also is seen *Chamæcrista brachiata Pollard, a tough-stemmed freely-branching plant, Solidago stricta Ait., and a depressed shrub, Bumelia angustifolia Nutt, with persistent leathery leaves shining above,

† Cf. *Olsson-Seffer, P.:* "The Genesis and Development of Sand Formations on Marine Coasts." Augustana Library Publications, No. 7, 1910, p. 18.

known as saffron-plum, ant's-wood, downward-plum. Low bushy forms of oak are found on the highest terrace of the upper beach growing with clumps of Yucca aloifolia L. So much for the vegetation of the beaches of northeastern Florida by way of comparison with those of the southern end of the state, which is found as indicated previously on essentially the same character of silicious sand.

Beach Formation, Ocean Beach Opposite Miami.—Several visits were made to the sea-beach opposite Miami, readily reached by small excursion steamer and now by a bridge across Bay Biscayne. It is situated on the peninsula that extends southward from the mainland, and in line with the Upper Sand keys, as Virginia, Biscayne and Soldier keys.

The width of the lower and middle beach on the Atlantic coast of South Florida is not as great as in North Florida, perhaps because of the steep offshore character of the land mass past which the Gulf Stream flows. The upper beach slopes gradually to the low dune on the crest of which the introduced cocoanut palm grows in an unbroken line along the shore. The upper beach is characterized by the long creeping stems of Ipomœa pes-capræ (L.) Sweet, associated with prostrate plants of similar habit, Canavalia lineata (Thunb.) DC. The grayish plant, Croton punctatus-Jacq., forms low clumps on the upper beach together with the silky canescent shrub, Tournefortia gnaphalodes (Jacq.) R.B., and Sesuvium portulacastrum L. The seaside-oats, Uniola paniculata L., covers the upper beach and extends over the crest of the frontal dune and a few clumps of the Spanish-bayonet, Yucca aloifolia L., are present to break the almost continuous growth of swaying grass panicles on long flexuous scapes.

Beach Formation, Sanibel Island.—Sanibel Island, separated from the mainland by San Carlos Bay, is at the mouth of the Caloosahatchee River and is the southwest island of the group which includes Captiva, Useppa, Gasparilla, and Pine islands. Its long diameter is approximately east and west. Its convex and south shore is exposed to the storms of the Gulf of Mexico, while its northern, or embayed irregular shore, is on the San Carlos Bay side. Two beaches, therefore, may be distinguished, which we will designate as the Gulf beach and the bay beach.

The vegetation of the exposed Gulf beach is somewhat different from that of the bay beach and will be described first (Plate I, Fig. 1). The lower beach is without visible living plants and is the widest of the three divisions of

the strand. The middle beach is marked by a great variety of univalve and bivalve shells and has a wet depression behind the shells washed ashore. It supports radiate masses of Sesuvium portulacastrum L., with pink flowers, together with the trailing spikegrass, Distichlis spicata (L.) Greene (Plate I, Fig. 1). The upper beach slopes gradually up to the outer dunes, and the vegetation of both blend together, so that it is difficult to make a sharp distinction between the plants typic of the upper beach and those found on the outer dunes. The characteristic plants of the upper beach are Ipomoea pes-capræ L. (Sweet), Canavalia lineata (Thunb.) DC., Pharbitis (Ipomoea) cathartica (Poir) Choisy, and the bur-grass, Cenchrus Carolinianus L. The Spanish-bayonet, Yucca aloifolia L., is found on the upper beach with occasional seaside-grape, Coccolobis uvifera (L.) Jacq., and buttonwood, Conocarpus erecta L. Several low shrubs are noteworthy as elements of the upper Gulf beach vegetation, viz., Lantana ovatifolia Britton, Ernodea littoralis Sw., and Scaevola Plumieri Vahl.

The bay beach of Sanibel Island follows the irregular curves of the shore. It is comparatively narrow and the lower beach is flat. The upper beach and the middle beach may be considered to merge, as the surf is of little consequence as a factor in shaping the beach form. Here the conditions are more favorable for the growth of beach plants than are those found on the Gulf beach. The absence of a strong surf, the reduction of the force of the wind, and the reduction in the salinity of the water caused by the entrance of the fresh water of the Caloosahatchee River, are all environmental differences which account for the greater variety of plants on the bay beach. On the bay beach are washed ashore masses of the water-hyacinth, Piaropus (Eichornia) crassipes (Mart.) Britton, introduced into Florida about 1890 at Edgewater about four miles above Palatka* and which has migrated across the state in a surprisingly short time. It reached the Caloosahatchee River by floating in rafts down the Kissimmee River from central Florida across Lake Okeechobee, through Three Mile Canal into the Caloosahatchee River, where it is found in large rafts that have finally floated out to sea, or been washed ashore, as at Sanibel Island upon the coastal islands. The captain of the steamer Gladys, which makes regular trips to the coastal islands, informed me

* *Webber, Herbert J.:* "The Water Hyacinth and its Relation to Navigation in Florida." Division of Botany, U. S. Dept. Agric., Bulletin 18, 1897.

FIG. 1.
Middle Gulf Beach, Sanibel Island, June 13, 1912, with patches of trailing spike-grass, Distichlis spicata (L.) Greene, and Sesuvium portulacastrum L. Original.

FIG. 2.
Mangrove vegetation along Miami River, August 12, 1911. Original.

that when the water hyacinth floats out to sea the salt water soon shrivels its leaves and kills it.

The bay beach was littered with fragments of shells, cases of sea urchins, etc. A reddish fiddler-crab by the tens of thousands scuttled over the beach with a rustling noise, which was intensified by the crabs knocking against the shell fragments and rattling them. After the phenomenal rains of June, 1912, the river water, charged with vegetal matter and mud, was of a dark chocolate color, even as far out as Sanibel Island, where it met the light greenish water of the Gulf in a sharp line of separation. The growing vegetation of the bay beach consisted on June 10, 1912, of the prostrate stems of Canavalia lineata (Thunb.) DC. in flower, and Ipomoea pes-caprae (L.) Sweet, in flower, both plants found in the new growth of the seaside oats, Uniola paniculata, associated with another grass, Distichlis spicata (L.) Greene. The herbaceous plants include Cyperus ottonis Bœckl., Atriplex cristata H. B. K. Dondia linearis (Ell.) Millsp., Sesuvium portulacastrum L. (a succulent), growing in thick mats, Chamaesyce buxifolia (Lam.) Small, Phyla nodiflora (L.) Greene, Melanthera deltoidea Michx., Bidens leucantha (L.) Willd. The presence of the succulent-stemmed Cactaceæ in Opuntia Dillenii Haw., Acanthocereus pentagonus (L.) Britt. & Rose and the leathery or succulent-leaved Agave decipiens Baker, Yucca aloifolia L. heightens the impression of a Litorideserta, or littoral desert.* The shrubs or low trees of the upper bay beach include Sabal palmetto (Walt.) R. & S., Coccolobis uvifera (L.) Jacq., Croton punctatus Jacq., Sophora tomentosa L., Conocarpus erectus L., Borrichia frutescens (L.) DC. All of these plants, herbs and shrubs alike, merge with the thicket vegetation to be described in detail in another section.

The beach at Punta Rassa across San Carlos Bay has a somewhat poorer flora. Here the most conspicuous species of the beach proper are Uniola paniculata, Canavalia lineata (Thunb.) DC., Ipomoea pes-caprae (L.) Sweet, Heliotropium polyphyllum Lehm., and Bradburya virginiana (L.) Kuntze. The shrubs that grow on the beach, or rather outer edge of the thicket, where they encroach upon the beach are seaside-grape, Coccolobis uvifera (L.) Jacq., and cocoa-plum, Chrysobalanus icaco L. This beach is rather exposed to the open waters of the Gulf of Mexico and to tidal currents

* *Brockmann, Jerosch H., and Rübel, E.:* "Die Einteilung der Pflanzengesellschaften nach Ökologisch-Physiognomischen Gesichtspunkten," 1912, 56.

which sweep past the point. The poverty of the flora may be due to these two conditions.

Consultation of the phytogeographic map accompanying this monograph will show that the silicious beaches in the restricted limits that we have chosen for our survey south of the 27° 30′ N. latitude are limited in number. They extend in front of Indian River to St. Lucie Inlet. From the St. Lucie Inlet to Jupiter Inlet the true strand is separated in some places from the mainland by a narrow channel of water connecting Indian River with Jupiter River. In the neighborhood of Jupiter, high dunes occur and the channel that stretches from Indian River to Lake Worth is still more constricted in width. The sand strand extends on the seaward side of Lake Worth as a narrow coastal island. The sandy foreshore from Lake Worth to Hillsboro Inlet was originally united with the mainland, being an integral part of it, but the coast survey map of 1911 shows a canal running back of the whole length of this part of the coast. The same conditions exist from Hillsboro Inlet to Ft. Lauderdale Inlet and from there to the head of Bay Biscayne, where the quartz sand peninsula extends southward to Norris Cut, opposite Miami. South of this are found two larger islands as Virginia Key and Key Biscayne, the last of the barrier beaches of silicious sands. The keys extending south to Key West have beaches of calcareous sand and belong to another category. Their vegetation has not been investigated carefully by the writer, and hence it is not included in this monograph. Presumably on the west coast Anna Maria Key, Long Key, Sarasota Key, and Casey Key, as far south as Casey Pass, have beaches of quartz sand similar to those of Sanibel Island. From Casey Pass, to the head of Lemon Bay the sandy foreshore is a part of the mainland. Then follow a number of elongated coastal islands, such as Gasparilla Island, and others, as far as Boca Grande. In front of Pine Island Sound and San Carlos Bay extend the chain of keys to which Sanibel Island belongs, including Lacosta and Captiva islands. South of Punta Rassa on the mainland the barrier beaches, including Estero Island, extend to Clam Pass. The shore north and south of Naples is part of the mainland, then, south of Gordon Pass, a series of costal islands are found that extend to Cape Romano, which is the southern extremity of one of them. The coast line from Cape Romano to Cape Sable is deeply embayed, or indented, and from reliable sources I learn that the islands which fringe it are mainly mangrove islands without sandy beaches until Cape Sable is reached. The immediate

shore line of Northwest Cape, Middle Cape, and East Cape (Cape Sable) are sandy. The south coast of Florida touching the Bay of Florida is fringed with mangrove swamps as far as Biscayne Bay. The description of the vegetation of Ocean Beach (Fairyland) on the east coast and of the beaches at Punta Rassa and Sanibel Island on the west coast may be taken as samples of the character of the vegetation of the sandy beaches on the east and west coasts of the southern end of the Florida peninsula respectively. The same may be said of the strand thicket vegetation of both coasts now to be described in detail.

Dune Formation.—The crest of the low frontal dunes on Anastasia Island is characterized by clumps of Yucca aloifolia L. mixed with densely massed evergreen bushes of Ilex vomitoria Ait. and other shrubs. The seaside morning-glory, Ipomœa pes-capræ, is a dune crest plant, as is also Croton punctatus Jacq., the prickly-ash, Xanthoxylum clava-Herculis L., the saw-palmetto, Serenoa serrulata (Michx.) Hook. and Solidago sempervirens. The hollows of the dense complex are occupied by masses of Yucca aloifolia L., Ilex vomitoria Ait., waxberry, Myrica cerifera L. [Cerothamnus ceriferus (L.) Small]. Isolated, partially prostrate, trees of the red-cedar, Juniperus (Sabina) virginiana L., are found. The seaside-oats, Uniola paniculata L., is common as a binder of the sands. The greenbriar clambers over the clumps of waxberry and Spanish-bayonets. The prickly-pear cactus, Opuntia austrina, Small, rises a foot above the surface of the dunes. A small rounded dune, as a relic of the dune complex, was left in a flat, featureless plain of sand because its top was protected by the Spanish-bayonet, Yucca aloifolia L., Myrica cerifera L., elderberry, Sambucus canadensis L., and Baccharis halimifolia L.

The dune complex at Ormond is covered with a thicket, but in front the frontal dune is highly elevated and cut by the wind into stretches of dunes, broken by depressions. Here grow dense masses of saw-palmetto, Serenoa serrulata (Michx.) Hook. (glaucous form), between which is the ever-present grass, Uniola paniculata L. Low, wind-swept trees of live oak, Quercus virginiana Mill, red-bay, Persea borbonia (L.) Spreng., waxberry, Myrica cerifera L., saffron-plum, Bumelia angustifolia Nutt., show the effect of strong winds on tree and shrub forms. In the spaces between the trees were found nearly a dozen specimens of a fleshy fungus, Clathrus sp., with a vile odor, suggesting its local names, "dead man's fingers," "buzzard's nose." Solidago semper-

virens L. and Chamæcrista brachiata Pol. enliven the dunes with the color of their flowers.

The low elevation above the upper beach at Fairyland, opposite Miami, may be termed a dune for want of a better name, but here it has been changed greatly by the planting of a row of tall cocoanut trees, Cocos nucifera L. The dune complex consists of a flat, slightly undulated surface of quartz sand, which extends clear across the peninsula to the edge of the mangrove formation which fringes the shore of the Bay Biscayne. The low trees, shrubs, and herbs of this area are in places widely spaced with sandy hollows and flat sandy intervals between the plants, while in other places the shrubs close together to form a low thicket.

Low, rounded palms, Serenoa serrulata (Michx.) Hook., are either isolated or they are found forming a tangled covering to hillocks of sand. The saw-palmetto frequently is found in the form with silvered, or glaucous leaves as well as the form with bright-green leaves. Another common shrub of the dune complex with plum-like, edible fruit is the cocoa-plum, Chrysobalanus icaco L. The seaside-grape, Coccolobis uvifera (L.) Jacq., forms low, widely spreading growths and is conspicuous with its broad, clasping leaves. The so-called sagebrush, Lantana involucrata L., with its showy flowers, is strongly redolent at times, especially when its leaves are crushed. As a growth form it suggests the shrubby species of Ceanothus common in the California chaparral, and ecologically, Lantana replaces Ceanothus on the dry dunes of South Florida. Croton punctatus Jacq. may be classified similarly from the standpoint of ecologic habitat. Two mimosaceous shrubs form part of the conspicuous growth of this dune complex. They are the unarmed shrub, called cat's-claw, Pithecolobium unguis-cati (L.) Benth., and the spiny blackbead, P. guadalupensis Chapm., that suggest the scrub of the Bahamas of which they are elements. The poisonous doctor-gum, Rhus toxiferum L. [=Metopium toxiferum (L.) Krug and Urban], is occasional as an element of the sandy strand vegetation, as also the unarmed shrub with pale bark, known as the seven-year apple, Genipa (Casasia) clusiaefolia (Jacq.) Griseb. Two rubiaceous shrubs, Erithalis fructicosa L. and Ernodea littoralis Sw., are noteworthy because they are covered by that curious climbing yellow and green vine with matted stems, Cassytha filiformis L., which much resembles the dodder. The leaves are scale-like, and the greenish-white flowers are in short spikes.*

* Cf. *Boewig, Harriet:* The Histology and Development of Cassytha filiformis L. Contributions rom the Bot. Lab., Univ. of Pa., Vol. II, 399–416, 1904.

Smilax Beyrichii Kunth and Smilax bona-nox L. also clamber over the shrubs and trees of this area, and Jacquemontia reclinata House is a trailing vine, while such fleshy-stemmed cactaceous plants as Acanthocereus pentagonus (L.) Britt. and Rose, Opuntia austrina Small suggest on a hot, bright day the desert flora of America and hence the name, Litorideserta, applied by Brockmann-Jerosch and Rübel to such a region, is appropriate. The spurge-nettle, Cnidoscolus stimulosus (Michx.) A. Gray, may be included in this category. A succulent herb, Sesuvium portulacastrum L., forms prostrate growths in the more open sandy stretches. The filling herbs, those that have no important biologic significance but simply grow between the more conspicuous shrubs and herbs and fill the spaces between them, are Remirea maritima Aubl., Raimannia humifusa (Nutt.) Rose, Gerardia purpurea L. [=Agalinis purpurea (L.) Pennell], Borrichia frutescens (L.) DC., Cirsium pinetorum Small, and Helianthus debilis Nutt. The dune complex, as far as the writer was able to discover, does not exist on Sanibel Island. The thicket formation meets the vegetation of the upper beach on both the bay and Gulf shores.

THICKET FORMATION

The stable, captured, or stationary dunes of Anastasia Island, called fossil dunes by some authors, are covered with a thicket, which, near the outer dune complex of shifting, or unstable, dunes, is a low thicket, or Krummholz of wind-swept oak trees with dead branch tips projecting upward above the living ones. The interlocking of the upper branches produces low, round-headed clumps of trees, which are usually massed together, or in some places they are separated by intervals of lower bushes or by exposed stretches of sand. Looked at from the top of Anastasia light-house (50 meters high), the bushland has a prevailing gray-green tone, and with the rounded tops of the trees a general billowy appearance. The general gray-green color scheme, however, is broken by dark-green patches of Juniperus (Sabina) virginiana L., Sabal palmetto (Walt.) R. and S., bull-bay, Magnolia foetida (L.) Sarg., and holly, Ilex opaca Ait. These dark-green areas provide a striking contrast to the gray-green colors of the gnarled, broad-headed oaks and other shrubs. The maqui of the Mediterranean, a form of coastal bushland, is strongly suggested by the thicket vegetation of the Florida coast and is related closely to the Mediterranean xerophytic evergreen scrub. How close the relationship may be ecologically future investigation will show.

Smilax sp. as a liane runs from low tree to low tree, contributing to make the jungle almost impenetrable, while Baccharis halimifolia L. grows in the forefront of the thicket. The Spanish-bayonet, Yucca aloifolia L., and Sabal palmetto (Walt.) R. and S. are scattered. Pinus caribæa Morelet is not infrequent. The prickly ash, Xanthoxylum clava-Herculis L., is a tree with its stem covered with prickles raised on corky bases. The denseness of this coastal scrub of low trees is enhanced by the masses of saw-palmetto, Serenoa serrulata (Michx.) Hook. The holly, Ilex opaca Ait., yaupon, Ilex vomitoria Ait. (I. Cassine Walt.), on Christmas Day, 1910, when Anastasia Island was visited, were bright with red berries. The bull-bay, Magnolia foetida (L.) Sarg., with large dark evergreen leaves is a conspicuous tree in the thicket at all times, especially in the winter. Beneath the large shrubs and trees were found three smaller shrubs, Myrica cerifera L., Vaccinium nitidum Andr. and Zenobia cassinifolia (Vent.) Pollard (=Andromeda speciosa Michx.). The herbaceous constituents of the scrub collected by me are a grass, Muhlenbergia filipes M. A. Curtis, and Houstonia rotundifolia (Michx.) in sandy areas, and Solidago angustifolia Ell. The heart of the strand forest on Anastasia Island is indicated by taller pine, oak, palmetto, and bull-bay trees with an undergrowth of saw-palmetto, Serenoa serrulata (Michx.) Hook. Here the woods on December 25th were as green as they are in July in the Philadelphia neighborhood. The leaves of the dominant constituents of the thicket are leathery, and in the live oak the edges are frequently curled. The tips of the branches, especially the laterals of the terminal branches, end in hard, spiny tips which is an expression of the xerophytism of the vegetation. The presence of many shrubs and trees with avivectent fruits, such as the bay, the holly, the yaupon, the red-cedar, and the waxberry, is without question due to the fact that migratory shore birds find covert in the depths of the bush, where they feed upon the juicy berries and drupes which they find on the plants there. Flying northward, or southward, from island to island, or in more sustained flight for considerable distances along the Atlantic coast, such species as the holly, Ilex opaca, and red-cedar, Juniperus virginiania, have a distribution far to the north.

The outer edge of the thicket formation which occupies the eastern end of Sanibel Island, extending west to a prairie that occupies its center, is characterized by such trees as the seaside-grape, Coccolobis uvifera (L.) Jacq., and buttonwood, Conocarpus erecta L. Low rounded shrubs compose the

vegetation of the outer thicket (Plate I, Fig. 1) as well as dwarfed trees. The most prominent of these trees and shrubs collected by me in the outer thicket on the Gulf side of Sanibel Island June 13, 1912, were Pithecolobium unguis-cati (L.) Benth., Jacquinia keyensis Mez. (in flower and fruit), Rapanea guianensis Aubl. (in fruit), Forestiera porulosa (Michx.) Poir, Metastelma scoparium (Nutt.) Vail, Lantana involucrata L. (in fruit), L. ovatifolia Britton (in fruit), while the trees and shrubs are draped with Virginia-creeper, Parthenocissus (Ampelopsis) quinquefolia (L.) Planch and poison-ivy, Rhus radicans L.

The thicket proper is an impenetrable mass of trees, shrubs, palms, and lianes, which bar the progress of the botanist. The shade is so dense that practically none of the herbaceous plants of the sandy beach can grow, and therefore the forest floor is bare, or is characterized by litter consisting of dead leaves of the palmetto, seaside-grape, and other overhead trees, but forest humus in the sense that that word is used in the deciduous forests of our northern states does not exist. The height of the tallest trees, which include Sabal palmetto (Walt.) R. & S., varies from 15 to 20 feet. The papaw, Carica papaya L., may be included as an introduced element of this thicket, which is without pine trees, and extends across the island to the bay shore. The outer thicket of the bay side of the island is characterized by the presence of such trees and shrubs as Suriana maritima L., Bursera simaruba (L.) Sarg., Jacquinia keyensis Mez., Psychotria undata Jacq., and the climber Melothria pendula L.

Physiognomically the thicket vegetation of Sanibel Island is similar to that described for Anastasia Island, but from the top of Sanibel light-house the impression that a botanist gets is a bushland of taller trees of a brighter green aspect, not so gray-green as the scrub of Anastasia Island. Perhaps owing to the more level surface and the more uniform crowns of the trees, the undulation of the forest cover is less noteworthy than on Anastasia Island.

Across San Carlos Bay, on the mainland at Punta Rassa, the thicket vegetation is taller and of larger trees. The forest here is not so uniform, because it is broken by salt lagoons, or flats, where the mangrove vegetation forms the exclusive growth, but on the higher ground the shore thicket is well developed and blends with the beach vegetation on the water side and with the forest proper on the landward side. The more important and conspicuous elements of this thicket collected by me on June 14, 1912, while waiting for

the mail boat, were the live-oak, Quercus virginiana Mill., with large trunk and spreading branches, catsclaw, Pithecolobium unguis-cati (L.) Benth. (in flower and fruit), Icthyomethia piscipula (L.) A. S. Hitchcock, an irregularly branched tree in flower and fruit with developing young leaves, Xanthoxylum fagara (L.) Sarg. (in fruit), and Randia aculeata L. A single vine was noted, Smilax Beyrichii Kunth. More attention will be given to the phenomenon of tropic vegetation, where there is apparently no cessation in flower and fruit production. Flowers are found on many of these trees and shrubs at the same time that the mature fruits are ready for dehiscence, or ready to fall, from the trees and shrubs. For such a phenomenon, I would suggest the name *antherocarpic*, from the Greek ἀνθηρὸς=flowering, and καρπὸς=fruit, rather than anthocarpic-anthocarpous, because the latter term is applied to fruits with accessory parts, sometimes termed pseudocarps, as the strawberry or pineapple. The use of the term *antherocarpic*, therefore, for the condition of a plant, which is flowering and fruiting at the same time, can have no ambiguity, especially if we attach the prefix syn (σὺν=with) and make it *synantherocarpic*.

MANGROVE VEGETATION

The ecology of mangrove vegetation is fairly well understood by phytogeographers and botanists. We owe much to A. F. W. Schimper, who published in 1891 in his "Botanische Mittheilungen aus den Tropen," a separate brochure entitled "Die indo-malayische Strandflora." Again in his "Pflanzengeographie auf physiologischer Grundlage," we have a detailed presentation of this highly important subject with a bibliography (pages 423–439). Later under the caption Littoral Swamp Forest—Mangrove, Warming in his "Oecology of Plants" (1909) gives a useful summary of the species of mangrove plants throughout the world and a statement as to the adaptation of the plants to their environment with a consideration of histologic structure. One of the latest general descriptions of mangrove plants is found in Holtermann's "In der Tropenwelt" (1912, chapter I). Phillips, Pollard and Vaughan have described the conditions of mangrove growth in Florida.* It is not with a hope of adding very much concerning the general character of mangrove plants

* *Phillips, O. P.:* How the Mangrove Trees add New Land to Florida. Journ. Geogr., II: 1–14; Vaughan, T. W.: The Geologic Work of the Mangroves in Southern Florida, Smithsonian Miscellaneous Collections, LII: 461–464.

that this chapter is written, but merely to give a detailed account of the general geographic distribution of the mangrove swamps, as well as a few points which the conditions of growth in Florida emphasize as important additional facts.

On the east coast of the state the northern limit of the red-mangrove, Rhizophora mangle L., which is the most characteristic mangrove of Florida, is approximately 27° 15′ N. The last trees of this species growing separated by considerable intervals from each other were seen along both banks of the St. Lucie River at Stuart. On the west coast, the mangrove vegetation does not extend beyond Tampa Bay at latitude 28° N., so that the northern limits on both the east and west coasts of southern Florida approximate the boundary which the writer has set as that of this monograph. The mangrove vegetation extends along the coast in the quieter water of the lagoons, the rivers, and the salt estuaries rarely exposed to the full force of the ocean surge.* In the enclosed bays, it gradually encroaches upon the shallow water until in the Whitewater Bay region of southwest Florida, we probably have an open shallow bay almost completely invaded by mangrove trees, which have formed islands separated by tortuous and labyrinthine channels of tidal salt water. The action of these trees in advancing the shore line has been described by a number of botanists. On the immediate east coast, the mangrove fringe is best seen along the shores of Bay Biscayne. It extends up the Miami River to where the river forks into a north and a south branch. (Plate I, Fig. 2.) Here observations made with the hydrometer indicate that fresh water prevails. Many of the lower flat keys, or mud banks, of the chain of islands extending to Key West are covered with mangrove trees, notably the red-mangrove, Rhizophora mangle L., with strong prop roots, and the black-mangrove, Avicennia nitida Jacq., with asparagus-like roots the thickness of the little finger. Such low flat trees with intricately crossed roots are important agents in fixing the muddy bottom, and it has been suggested to plant these trees along the new embankments of the "oversea" railroad to Key West to prevent the wash of the waves and the undermining of the banks.

Mangrove vegetation was noted along the following Florida keys: Card Sound is mangrove fringed and so is Barnes Sound, as seen in crossing from the mainland to Key Largo via the drawbridge over Jewfish Creek. Blackwater Sound is surrounded by the mangrove formation. The northern

* On good authority, it occurs on the ocean side of Virginia Key and Key Biscayne.

and southern ends of Key Largo are low and covered with mangroves. On this island, the low salt flats are controlled by the black-mangrove, Avicennia nitida Jacq., and wherever a salt channel is reached, such a channel is lined with red-mangroves. Long Key has a large reëntrant bay at its northern end with its shore lined with this type of littoral swamp vegetation. My notes of June, 1912, continue the observations from Long Key, which was visited in December, 1910. Grassy Key is mangrove fringed and has mangrove flats. The lower end of Key Vaca is a mangrove flat, while Little Duck Key is almost entirely a flat covered with mangroves. Bahia Honda Key has flat mangrove areas and salt lagoons with islands of these trees raised on their stilt-like roots. Similar flats and fringing mangrove swamps are found on Summerland, Big Pine, Cudjoe, Sugar Loaf, Saddle Bunch, Big Coppit keys, followed by a succession of low mangrove islands around Rockland and Boca Chica keys, while Key West is partly fringed with a dense, impenetrable thicket of low mangrove trees not over 3–3.5 meters (10–12 feet) tall.

The south shore of the peninsula of Florida, touching the Bay of Florida, as far as Flamingo, is bordered by a dense and wide mangrove thicket, which extends north until it blends with the coastal prairie-everglade. Here the thicket begins to thin out and the trees become scattered.* These scattered trees extend some distance back into the coastal prairie-everglade where they become smaller, lower (not over 1 meter tall), and reduced to a few leafy branches raised on widely extended prop roots. (Plate II, Fig. 1.) The leaves assume here a yellowish-green color. Here the trees grow in fresh water and their presence is due to survival from a time when the mangrove swamp covered all of the southern end of the peninsula. As the dry-land conditions became more pronounced, the northern edge of the coastal swamp was invaded by prairie-everglade vegetation. The mangrove trees were gradually suppressed until surrounded with grass and sedge vegetation and almost completely choked by it, a few low, scattered mangrove trees of a yellowish-green color remaining under the stress of the competition of the everglade-prairie plants. (Plate II, Fig. 1.)

The uncertainty as to the outline of White Water Bay, Ponce de Leon Bay and the Bay of Ten Thousand Islands is on account of the islands of mangrove

* Compare the accounts of *Harper, R. M.:* Report on Peat, Third Annual Report Florida Geological Survey, 228, 233, 327; Tramping and Camping on the southeastern Rim of the Everglades Florida Review, 4; 154–155. 1910.

trees separated by labyrinthine channels of salt water, so perplexing in their ramifications that no surveyor has even attempted to map their position. As the mangrove trees are invading constantly fresh territory, these bays, which probably existed when the earliest maps were made, have been invaded gradually until their original outline has become indefinite.* As bays, they no longer exist, for a tree-top observation of Dr. John K. Small from the extreme westernmost everglade key failed to note the presence of any open water where White Water Bay should be. As names on the map, they have been copied by each compiler, so that no two maps agree as to the exact shore line of these so-called bays. The probable correct character of them is shown on the phytogeographic map which accompanies this monograph. At least, the map is a conservative representation of the geography of the southwest coast of the peninsula.

Low mangrove thickets extend up the Caloosahatchee River some distance above Ft. Myers, where the river narrows just below Olga. Here in the river are several islands with mangrove vegetation gradually blending with flat areas covered with cat-tail, Typha angustifolia L. About here the red-mangrove, Rhizophora mangle L., loses its hold in competition with river-bank plants controlled by fresh water. The mouth of the Caloosahatchee River is filled with low mangrove islands, and as previously mentioned low thickets of these trees extend north as far as Tampa Bay. Along the protected bays and lagoons formed by the outlying sand keys a dense fringe of mangroves is found, which continues with but slight interruption to the southern end of Charlotte Harbor.†

Physiognomy of Mangrove Vegetation and Constituent Plants.—Mangrove vegetation seen from the water surface along which it is found appears as a dark-green, dense thicket of low trees with rounded or spreading tops and with numerous arched aërial roots, which grow downward into the shallow water, or into the flat, muddy bottom where the water is relatively calm, as in lagoons, inlets, bays, and estuaries. The soil, which is muddy, rarely rocky,‡ is flooded with water either permanently or at high tide. As we have seen in the case of the Miami and Caloosahatchee rivers, mangrove vegetation extends a considerable distance inland. The aërial prop roots of the red-mangrove are character-

* *Sanford, Samuel:* Second Annual Report, Fla. State Geologic Survey: 194.

† Cf. *Heilprin, A.:* Exploration on the West Coast of Florida, Proc. Wagner Free Institute of Science, 1887.

‡ Dr. Roland M. Harper has seen Rhizophora on the exposed rocky shore of Lower Matecumbe Key, but its roots had a hard time in getting a foothold in the rock.

ized by wart-like lenticels and on them cling oysters and a large amount of floating material, while mud and sand carried by ocean currents are deposited among the intricate complex of roots, and gradually the shore line advances seaward. While the foliage of the red-mangrove is dark-green and lustrous, that of the black-mangrove is of a grayish-green color. The latter is a low spreading tree found on the tidal flats out of the muddy soil of which the pencil-thick, asparagus-like pneumatophores project. These vertically directed root branches may be submerged with the rising tide, or may be in drier situations exposed constantly to currents of air.

The mangrove formation was studied at a number of localities in South Florida. Back of Fairyland Beach, opposite Miami, and along Bay Biscayne, we find the shore fringed with red-mangrove, Rhizophora mangle L., associated with the black-mangrove, Avicennia nitida Jacq. The flat tidal, more open areas are characterized by the spreading, prostrate, pale-green patches of the saltwort, Batis maritima L. The light-green of this low, woody plant contrasts strongly with the dark green of the overhead mangrove foliage. The buttonwood, Conocarpus erecta L., is found as an element of the inner edge of the thicket, as well as Baccharis angustifolia Michx., while along a line where the swamp meets the higher ground it is bordered by a low shrub, Borrichia frutescens (L.) DC. and clumps of a sedge, Fimbristylis Harperi Britton.

The mangrove vegetation that lines both banks of the Miami River (Plate I, Fig. 2) up to its fork, where the swift current has laid bare the limestone rock where the mangrove hardly maintains itself, consists of the dominant red-mangrove, Rhizophora mangle L., black-mangrove, Avicennia nitida Jacq., and buttonwood, Conocarpus erecta L., with which are associated the red-berried dahoon, Ilex cassine L., the cocoa-plum, Chrysobalanus icaco L., Baccharis angustifolia Michx. and B. glomeruliflora Pers. The mangrove border, which is not over 50 feet wide, is not a continuous strip, but is broken by grassy stretches and by areas dominated by the cat-tail, Typha angustifolia L. A tall fern with heavy fronds, Acrostichum aureum L., is conspicuous as a mangrove species. An aquatic plant, Sagittaria lancifolia L., becomes more common along the shore as the mangrove clumps become less frequent. Saw-grass, Cladium effusum (Sw.) Torr. [=Mariscus jamaicense (Crantz) Britton], Typha angustifolia L., and Rhizophora mangle L., alternate with each other. A species of bladderwort, Utricularia oligosperma St. Hil., floats on the water in front of the low mangrove trees at the fork of the river.

The mangrove formation along Billy Creek, a stream which empties

into the Caloosahatchee River at Ft. Myers, has the usual round-topped character. The dominant mangrove tree is Rhizophora mangle L. with its opposite, leathery leaves of a dark-green color and its pendent, plummet-like embryos hanging out of the ripe fruit. Associated with the mangrove and growing out of the muddy ooze of the stream bank are the buttonwood, Conocarpus erecta L., three species of shrubby Baccharis, viz., B. angustifolia Michx., B. glomeruliflora Pers., and B. halimifolia L., with such herbaceous plants as a grass, Distichlis spicata (L.) Greene, two sedges, Cyperus ferax Vahl, Fimbristylis Harperi Britton, Lythrum lineare L., Rhabdadenia biflora (Jacq.) Muell. Arg, Phyla nodiflora (L.) Greene, Monniera monniera (L.) Britton, Aster carolinianus Walt., Pluchea purpurascens (Sw.) DC., and the yellow compositous shrub, Borrichia frutescens (L.) DC. (in flower and fruit). A gray lichen, Parmelia latissima Fee, is found attached to the trunks of the mangrove trees, as also an undetermined species of Arthothelium and a Physcia, perhaps P. stellaris. The large fern, Acrostichum aureum L., is an element of the mangrove thicket along Billy Creek, and the water-hyacinth, Piaropus crassipes (Mart.) Britton, drifts in between the arched roots of the trees that line the shore. As this plant is so abundant in the rivers and lakes of Florida, it is suggested that it might be gathered and spread on the sandy fields of the state as a fertilizer, supplying by its decay a certain amount of humus to such soils.

Instrumental Study of the Mangrove Formation.—The better to judge of the exact conditions which control in the mangrove thickets several instruments of precision were carried to South Florida on the last two trips. An hydrometer, reading to four decimal places, was used to determine the salinity of the water, a soil thermometer to get the temperature of the mud about the roots of the trees, an air thermometer to secure the temperature of the air and an hygrometer to test the humidity of the air. The hydrometer readings are most instructive, and the other data while very incomplete serve as an index of conditions that may prevail in the thicket at noon on a bright sunny day. The hydrometer readings are given below:

	Sp. gr.	*Temp.*
Ocean water, surf at Fairyland	1.0240	30°
Bay Biscayne water, Mangrove Area	1.0235	30°
Water at mouth of Miami River	.0999	27°
Mangrove border, Miami River	.0999	27°
Halfway up, Miami River	.0999	27°
Water at fork of Miami River	.0999	27°
Water at outlet of Everglades	.0998	28°
Everglade water in Miami Branch Canal	.0997	31°

Apparently, we have from these figures, the red-mangrove trees growing with their roots exposed to fresh water conditions and yet until we reach the fork of the Miami River, the trees retain their usual form and usual height. How is this to be reconciled with the hydrometric readings of the surface water? The explanation seems to be that the salt water, which flows into the Miami River from Biscayne Bay, is denser than the fresh water which flows from the Everglades. Hence the fresh water flows out on top of the salt water, which is beneath. The lower parts of the roots may be influenced by salt water, while the upper part of such roots is bathed with fresh. It will be noted that the temperature of the river water is colder than either that of the Everglades, or that of Biscayne Bay. No correction was made in these hydrometric readings for differences in temperature, so that the figures are only approximations. At Billy's Creek at 11 A. M. on a bright sunny day, June 4, 1912, the air temperature of the mangrove thicket was 90° F. (=32° C.), and the relative humidity 72%, while in the neighboring salt marsh the air temperature was 96° F. (=35° C.) and the humidity 72%, just before a violent thunderstorm after which the temperature dropped to 78° F. (=25.6° C.) in 20 minutes.

Another fact of considerable interest previously mentioned in a description of the general distribution of mangrove vegetation is the gradual replacement of mangrove trees by the encroachment of the saw-grass vegetation of the coastal prairie-everglade and by the saw-grass vegetation of river-bank marshes along the Miami River. The shore line of the extreme southern end of Florida is fringed by mangrove swamps, and back from the Bay of Florida the thicket begins to thin out and as we proceed inland the red-mangrove trees become scattered. Between these scattered trees the saw-grass vegetation of the coastal prairie-everglade has invaded, and with the increase of fresh water conditions, which in itself is not inhibitory, the mangrove trees become shorter, smaller, with few branches and leaves that begin to assume a light, yellowish-green color. Finally in the competition with the saw-grass vegetation, the mangrove is worsted and gradually thins out and disappears. This fact is also demonstrated along the Miami River. On the river banks the mangrove trees are of the usual size, but back from the river in wet depressions controlled by fresh water and saw-grass, the mangrove trees become low, sparingly branched bushes, widely arched and extended prop roots, yellow-green leaves. This change in vegetation has an

important bearing on the consideration of the succession of vegetation types in South Florida.

SALT MARSH FORMATION

True salt marshes, such as exist along the open bays and estuaries of the North Atlantic coast of North America and of similar physiognomy, exist in the southern coastal states according to the observations of the writer near Charleston, South Carolina, Savannah, Georgia, Jacksonville, and St. Augustine, Florida, where notes were made of the principal species of plants. It was noted that Spartina stricta (Ait.) Roth (=S. glabra Muhl.), as in the north, fringes the open channels, while as associated elements of this vegetation we find Salicornia ambigua Michx., Atriplex hastata L., Distichlis spicata (L.) Greene, and Baccharis halimifolia L. Such species as Juncus Roemerianus Scheele, Batis maritima L., Iva frutescens L., and Borrichia frutescens (L.) DC. are constituents. The rough map of the plant formations of the east coast of Florida made as a result of three trips to the south indicates that salt marshes of the usual type occur as far south as Cape Canaveral (opposite Titusville) in latitude 28° 30′ North, and probably, although the notes do not give any data, as far south as Indian River Inlet, 27° 30′ North. Such salt marshes are north of the extreme northern limit of the red-mangrove, Rhizophora mangle L., which, as previously intimated, ranges north to the St. Lucie River in latitude 27° 10′ North. Indian River Inlet, therefore, represents approximately the southern limit of true salt marshes uninfluenced by mangrove vegetation.

The salt marshes of the west coast of southern Florida were noted after passing Fort Ogden along the Peace River and Charlotte Harbor, where they blend with the palmetto savannas in some localities and with pine savannas in others. The most conspicuous elements of these salt marshes are Juncus Roemerianus Scheele in pure association and the tall fern, Acrostichum aureum L. The tension line between the typic salt marsh and the saw palmetto formation with a few scattered pines is a very sharp one. A difference of 30 centimeters in surface level is sufficient to alter the physiognomy of the vegetation entirely. At Punta Gorda is found a pine savanna blending with the nearby salt marsh formation. Similar salt marshes are found along Billy Creek near Ft. Myers. Here the concave bend of the stream is occupied by mangrove vegetation, while across the creek the convex curve is characterized by a salt marsh,

where the rush-grass, Juncus Roemerianus Scheele, of a deep, brownish-green color, is dominant, associated with Cyperus sp., the tall fern, Acrostichum aureum L., sea-lavender, Limonium sp., Phyla nodiflora (L.) Greene and a climbing apocynaceous plant, Rhabdadenia biflora (Jacq.) Muell. Arg. The margin of the salt marsh shows the presence of Sabal palmetto (Walt.) R. & S., Yucca aloifolia L., buttonwood, Conocarpus erecta L., which constitute the tree vegetation conspicuous across the open marsh as a boundary line. The shrubby associates of the trees that break the sky line are Myrica (Morella) cerifera L., Baccharis glomeruliflora Pers. with broad leaves, and B. angustifolia Michx., with narrow leaves, while Borrichia frutescens (L.) DC. lines the space between the fringing thicket and the open salt marsh. Instrumental readings on this salt marsh on a bright sunny, but sultry day—on June 4, 1912—gave at 11 A. M. the following data:

Humidity of air	72 %
Temperature of air	96° F. = 35° C.

A thunderstorm which came at 12 M. caused the temperature to drop to 78° F. in twenty minutes.

The salt marsh facies, although perhaps controlled by fresh water, occurs along Hancock Creek, which empties into the Caloosahatchee River on the north bank of that river, opposite Ft. Myers. The reason for including this marsh vegetation with that of salt marshes is because of the dominancy of the coarse rush-grass, Juncus Roemerianus Scheele, which in pure association edges the stream, while in other places it is fronted by the tall tropic fern, Acrostichum aureum L. This type of marsh extends back to the sinuous line of the pine forest fronted by the palmetto in an almost unbroken strip. It is characteristic for the palmetto hammocks to stand in front of the pineland and on the salt marsh side. There are single palmettos in the salt marsh here and detached clumps of them nearer the pines. Typha angustifolia L. forms associations touching the bank of the creek, as also the elder, Sambucus canadensis L., as a synantherocarpic plant on June 17, 1912. The red-mangrove, Rhizophora mangle L., is a border tree, as also the custard-apple, Annona glabra L. Ascending the creek, this vegetation gives way to pineland and hammock land.

SAND-PINE FORMATION (ROSEMARY SCRUB)

On the east coast of Florida are rolling sand plains and sand hills with broad swales filled with shallow lakes, wet prairies, cypress swamps and flat

pineland with slash-pine, Pinus caribaea Morelet. This sand region extends from the north side of Indian River Inlet south to Hillsboro Inlet, and it consists of fine wind-blown sand derived from the sand deposited along the coast by the southward-moving oceanic currents. The evidence of this wind action is seen in the ancient dunes, or ridges, related in origin to the coastal dunes. The sand deposits have covered an older, flat land of limestone, which is seen in the valleys, or swales, between the ridges and along the Everglades, where the monotonous level of the flatland and the prairies denotes the earlier surface. The flat lands with their covering of slash-pine, Pinus caribaea Morelet, are older geologically and their vegetation is older to the region than that of the rolling sand hills and sand plains with their covering of sand-pine, Pinus clausa (Engelm.) Vasey. As far as the evidence at hand will permit one to judge, the encroachment of the coastal sand deposits caused the destruction of the pine forests and vegetation of the older flat limestone surface by wind-blown sand. Subsequent to this period, the sand pine vegetation gradually spread over the inland deposits of dune sand. The original land surface is also determined by a study of the lakes, several miles long, that occupy depressions in the older limestone land. The possible maximum width of the sand deposits in east Florida is not over 9 kilometers.

The dominant tree of this region is the sand-pine or spruce pine, Pinus clausa (Engelm.) Vasey, not over 6 to 9 meters tall and with its stem in some localities, as at Palm Beach, inclined to the west, because of the prevailing east winds (Plate II, Fig. 2). This tree with relatively smooth bark is branched close to the base with spreading, or upward directed branches, and in its habit of growth it suggests the scrub-pine or Jersey pine, Pinus virginiana Mill. The crown of the sand pine is a fairly close one. The stand may be dense in some spots and in other places wide-spread, so that plenty of sunlight reaches the forest floor. The intolerant pines form the upper story in an exclusive or pure stand. The tolerant species that form the second story are several evergreen oaks which remain as shrubs and small trees beneath the shade of the pines. A low oak, Quercus geminata Small, with pale-gray, furrowed bark, is a conspicuous element, but as a suppressed growth, it never reaches above the crown of the spruce pines. As a shrub, it has narrowly oblong, elliptic, or oblong-lanceolate, revolute-margined, leathery leaves and is an important part of the undergrowth of the rosemary scrub. Another much-branched evergreen shrubby oak is Quercus myrtifolia Willd., with a smooth bark and leathery

obovate or oval leaves. Quercus minima (Sarg.) Small with underground stems occurs in the scrub near Ft. Lauderdale. Quercus Chapmanii Sarg. is a rigid shrub with a dark bark which splits into irregular plates. Its leaves are obovate, or oblong, thick, smooth and lustrous on the upper surface and sparingly pubescent on the under surface. The spaces between the low oaks are filled with the glaucous, or silvered, form of the saw-palmetto, Serenoa serrulata (Michx.) Hook., which, growing out of white sand, gives a heightened effect to the prevailing grayish or white tone of the forest floor (Plate II, Fig. 2). The prevailing color tones of the forest are the bluish-green hues of the pines, the lighter and darker greens of the oaks and the grayish-white color of the lower layer, which is also enhanced by the gray lichens to be described later. Here and there, however, the gray tone is splotched with dark-green, especially when the forest is open and the sand relatively bare of other vegetation. Such open places are characterized by the candelabra-like, branching rosemary, Ceratiola ericoides Michx. (Plate V, Fig. 1), an empetraceous shrub, which with the pines is a character plant of these barrens, known locally as rosemary scrub. The heather-like rosemary is related to a low shrub, Corema Conradii Torr., of rounded or cushion-like form, found on the plains of New Jersey, in several places on the heaths of Nantucket, and on the rocky islands off northern New England. Like Corema and Empetrum, Ceratiola has small revolute leaves, so that they are narrowly linear, or filiform, subulate. Sections that the writer has made of the leaves of the three genera show under the microscope a typic roll structure with the stomata on the under surface, thus opening into an air-still chamber. The rosemary is an erect, evergreen shrub with whorled branches and reddish, dioecious flowers. Outside of the sand hills of the east coast, it was noted by me in similar barrens with Pinus clausa and Serenoa serrulata between Auburndale and Lakeland in the western part of Polk County under similar edaphic conditions. On good authority, rosemary scrub is found back of Naples in the western part of Lee County. Similar scrub was studied by Nash* in Lake County, central Florida. There beneath Pinus clausa (Engelm.) Vasey are low oaks in abundance associated with Ceratiola ericoides Michx., Persea humilis Nash, a shrub or small tree with brown, silky pubescence, Bumelia lanuginosa (Michx.) Pursh, Ximenia americana L., and the climbing vine, Smilax Beyrichii Kunth, which grows

* *Nash, George V.:* Notes on Some Florida Plants. Bulletin Torrey Botanical Club, 22: 144, April, 1895; also *Mohr, C.:* Plant Life of Alabama. Contrib. U. S. Nat'l Herb., VI: 112, 130, 599.

PLATE II

FIG. 1.

Dwarf mangroves growing in saw-grass marsh, north side of the Miami River, August 16, 1911. Similar low mangroves are found on the coastal prairie south of Detroit. Original.

FIG. 2.

Sand-pine (Pinus clausa) forest at West Palm Beach, August 10, 1911, with an undergrowth of low oaks and saw-palmetto. Original.

FIG. 3.

Pine forest south of Homestead, August 15, 1911, showing even stand of slash-pine, Pinus caribaea Morelet, and silver palm, Coccothrinax Garberi (Chapm.) Sarg. Note the angular limestone rock fragments, the saw-palmettos, etc. Original.

FIG. 4.

Roots of palmetto denuded of soil by the currents of the Caloosahatchee River. Photograph by S. L. Schumo.

over the scrub oaks. Breweria grandiflora A. Gray is a beautiful plant noted by Nash, with large, bright-blue flowers whose stems, sometimes 2 to 3 meters long, cover the ground in all directions. Grasses are absent and only one sedge is found, viz., Rhynchospora dodecandra Baldw., which is quite common. Fires are infrequent, but if they do occur, they are very destructive to the scrub vegetation more than in the pine forest of slash-pines.

Data as to the general distribution of Ceratiola in the southern states were obtained from the sheets of the plant in the Herbarium of the New York Botanical Garden and from papers by Dr. Roland M. Harper. From south to north the localities are:

Florida.

Ft. Lauderdale, Dade County.
Delray, Palm Beach County.
Lake Worth, Palm Beach County.
Manatee, Manatee County.
Indian River, Brevard County.
Eustis, Lake County.
St. Petersburg, Pinellas County.
Cedar Keys, Levy County.
St. Augustine, St. Johns County.
St. Johns River, St. Johns County.
Pablo, Duval County.

Georgia.

Fifteen Mile Creek.
Rosemary Church, Emanuel County.*
Augusta, Richmond County.

South Carolina.

Between Columbia and Perry, Lexington County.†

Alabama.

Citronelle, Mobile County.
Dauphine Island, Mobile County.
Spring Hill, Mobile County.
Washington County.

Mississippi.

Hebron Island.
Petit Bois Island.

* *Harper, R. M.:* Botanical Explorations in Georgia during the Summer of 1901, Bull. Torr. Bot. Club, 30: 285.

† *Harper, R. M.:* Some Aspects of Coastal Plain Vegetation. Bull. Torr. Bot. Club, 38: 235.

If we consult the map of the distribution of Pinus clausa (Engelm.) Vasey included in the first part of Sudworth's Forest Atlas, Geographic Distribution of North American Trees (U. S. Forest Service, 1913, Map No. 29), we discover that the distribution of Ceratiola as given above is partially coincident with that of the sand-pine, although the range of Ceratiola is greater than that of the pine (Plate V, Fig. 1). Given one of these two plants in an area, we may expect to find the other hard by. Such coincidences of distribution are not rare in ecologic study, as, for example, the association of the hemlock, Tsuga canadensis (L.) Carr, the round-leaved violet, Viola rotundifolia Michx., and Lycopodium lucidulum Michx. That such coincidences in the association of plants are not due to chance, but are due to an accommodation of certain associated plant species to the same environmental factors has been abundantly proved, not only in these isolated cases, but in other regions and in other vegetation types as well. If our plant distributional and ecologic studies mean anything, they should enable us to postulate what the associations of plant species should be, given certain edaphic, biologic and climatic conditions. It is incumbent upon the ecologist to match climates, to discover what the interrelationship of plant species is, not only with species associated in the same formation, but also with the same climate and soil. In the determination of such factors by accurate instrumentation and experimentation, so that we may predict what kind of vegetation may be expected given certain conditions of environment, lies the possibility of making ecology an exact science.

A low, ericaceous shrub, Vaccinium nitidum Andr., occurs in the scrub at Ft. Lauderdale. The oaks, rosemary and other plants, such as, Xolisma fruticosa (Michx.) Nash, Palafoxia Feayi A. Gray, are festooned, or draped, with the stringy branches of the yellow, or reddish orange, leafless parasite, Cassytha filiformis L. Although this parasite is not confined to the rosemary scrub, but is found on plants of the flat pineland and sea dunes, yet it is a striking element of the sand pine forest not only in its yellow, or reddish-orange color, but also in its peculiar habit of growing from bush to bush and plant to plant like Cuscuta until they are enmeshed by the twining, slender, cord-like stems, sometimes matted together like a snarl of yarn. The bushes are ensnared like a lion in a hunter's net, or like a fly in the meshes of a cobweb. Like Arachne, Cassytha spins its yellow threads over the herbs and shrubs of the forest. The Virginia-creeper, Parthenocissus (Ampelopsis) quinquefolia (L.) Planch. and Vitis Munsoniana (Simps.) Small, are common lianes

in the sand-pine forest. Of the plants with a striking xerophytic structure may be mentioned Opuntia austrina Small, with flat joints, two feet tall, and the Spanish-bayonet, Yucca aloifolia L.

The herbaceous plants of the sandy soil as a third layer grow out of a leaf litter two inches thick which covers the forest floor beneath the pine trees. The two most common herbs collected by me at West Palm Beach on August 10, 1911, were Polygonella polygama (Vent.) A. Gray and Afzelia pectinata (Pursh.) Kuntze, while on some waste material at the edge of the forest grew the balsam-apple, Momordica charantia L. The earth-star, Geaster sp., was found as an element of the fourth or ground layer of the forest. The white sand of the rosemary scrub formation is either covered with pine needles and other litter, or with plant growth. Here and there are bare stretches of white sand with several gray lichens forming part of the fourth layer. Three species of Cladonia, determined by Prof. Bruce Fink, are found. They are Cladonia sylvatica (L.) Hoffm., which grows in rounded, spongy cushions, Cladonia alpestris (L.) Rabenh., a fine gray lichen, and Cladonia leporina Fr., a coarse gray lichen.

The vegetation of these ancient sand dunes is essentially xerophytic, because the water, which falls as rain, rapidly percolates through the sand. The radiation of the sun is also quite intense, especially the noonday glare, and the wind action must be considerable, as the pine trees incline inland in some places at considerable angles. The soil of these sand hills is well adapted to the growth of the pineapple and some of the largest pineapple plantations in Florida are found in this region. A few plantations are of such size that small cars, drawn by mules and men on wooden tracks are used to collect the fruit from distant parts of the sandy fields. The pineapple is the crop for such areas and its cultivation is being extended rapidly, so that in time the natural forest of sand pine and associated vegetation will be cleared to make room for pineapple fields.

SLASH-PINE (PINUS CARIBAEA) FORMATION

The exposures of oölitic limestone, which we have named and described in the section on Geology, the Miami-Key West oölite, are covered in the main with the slash-pine tree, Pinus caribaea Morelet, which also extends much farther north on other types of soils. The outcrops of oölotic limestone extend

from Delray on the east coast south to Detroit in Dade County and the low ridges of this rock separate the Everglades from the mangrove swamps and salt prairies along the western shore of Bay Biscayne. Along the western edge, the outcrops slope gradually to the level of the Everglades and at their southern extremity a sharp western bend is made where the limestone tapers off to a series of rocky keys, or islands, surrounded by saw-grass vegetation. Long Key is the largest of these rock islands, which extend fully 24 kms. beyond the southwest corner of the larger groups of similar islands. The hard rock outcrops west of the Everglades are more scattered than on the east coast, but cover a wider extent of country. The region of pine islands and cypress swamps is characterized by projections of limestone through the sandy mantle. Such outcrops are found along the roads from Ft. Myers to Ft. Shackleford and from Ft. Myers past Immokalee to the head of Allens River. There are also areas of bare rock, which extend as narrow, interrupted strips of varying length up to several miles through the pineland. The limestone on the west coast is denser and finer than on the east coast, so that it weathers irregularly into rounded knobs, which project several inches to a foot above the surface. On the east coast, the softer, oölotic limestone weathers into sharp, angular fragments which lie loosely on the surface, or it is eaten into pockets filled with sand, which accommodate various plants of the region (Plate II, Fig. 3). The surface, therefore, is very rough and uneven, and owing to the honeycombed character of the rock, in some places full of larger and smaller pot holes, walking through the forest is dangerous, especially, too, as loose fragments strew the surface and rattlesnakes are found sometimes. There has been solution underground as well and the holes which have been formed, and which communicate with underground channels, are of all sizes. Some of them are known as banana holes (Plate III, Figs. 1 and 2) and will be described later with their vegetation. Deep Lake on the west coast, twelve miles east of Everglade Post Office, is a great limestone sink filled with water. The low, natural rock bridge of Arch Creek and the Punch Bowl are evidence of such solution. The pineland is intersected by rivers that have been described in the geographic section. South of Larkin, narrow transverse prairies extending west almost or quite to the Everglades separate the pineland into islands. These prairies vary in width and their appearance and vegetation will be left for subsequent treatment.

The pine forest consists of tall slash-pine trees, Pinus caribaea Morelet, of

PLATE III

FIG. 1.

Third banana hole, north of Naranja, Fla., August 18, 1913. Original.

FIG. 2.

Fourth banana hole, north of Naranja, Fla., August 18, 1913. Original.

even stand with an open crown admitting the light to the forest floor beneath (Plate II, Fig. 3, Plate IV). The trunk of the dominant pines is straight, tapering upward to a maximum height of 35 meters. The trunk diameter may reach 1.5 meters, but in the forest there are all ages of growth, so that the diameters vary widely. The bark of these trees is split into broad, flat, irregular plates (Plate III, Fig. 2) covered with reddish-brown scales; the inner layers are yellowish-gray to orange-brown and ball-like lumps of hardened resin is found on some of the trees. If one stands in the center of the forest and looks around, he sees in some places sandy soil covering the oölitic limestone, in other places, the rough nodules of the limestone projecting through the surface soil between the pine trees and the light-greens or dark-greens of the scattered saw-palmettos, shrubby and herbaceous vegetation of the forest floor (Plate IV). Above he sees the serried columns of the pine trees, which as they close together in the perspective distance, depending upon the closeness of the stand, give a flat, reddish-brown, background color, while above the crown of the trees against the blue of the sky, or against the woolly white cumulus clouds, is a prevailing yellowish-green color. The flowers open in January and February before the new leaves appear, so that in these months the prevailing color of the foliage above is lighter than at any other season of the year after the leaves which last about two years have become of adult size and color. In some districts where the trees are tapped for the small amount of crude turpentine, which they yield, the areas from which the bark has been cut to remove the turpentine are conspicuous as one looks in any direction through the forest of this handsomest of southeastern pines, known in different localities as bastard-pine, meadow-pine, pitch-pine, she-pine, slash-pine, spruce-pine and swamp-pine.

Reproduction of this pine is generally very good. The seeds germinate readily into vigorous seedlings which grow rapidly and take entire possession, even with the presence of other competing species of pines. It promises to replenish the forest areas with young trees, which in forty years are ready for tapping, and which yield a wood with a coarse grain, easily infiltrated with creosote and other preservatives. Thus in the short time of forty years, a new forest replaces the old one. On the west coast, south and north of the Caloosahatchee River, the slash-pine mingles with the long-leaf pine, Pinus palustris Mill, which north of Punta Gorda and the east head of Charlotte Harbor is the dominant tree in pure forest except for a slight admixture of Pinus

caribaea Morelet. South of Punta Gorda, Pinus caribaea Morelet becomes more abundant and exclusive.

The undergrowth in the slash-pine forests of the east coast and the west coast exists in three, or four, layers. The second layer consists of shrubs and low trees, none of them reaching to the lower branches of the dominant pine trees. Hence the forest appears to be an unusually open one, because the view is unobstructed by the bushes that in many denser forests close together and fill up the spaces between the taller trees. The constituent elements of the undergrowth vary from place to place. Along the east coast, although edaphic conditions of the oölitic limestone soil are very similar, there is considerable diversity in the typic shrubs of the pineland. When we contrast this with the secondary plants of the west coast, we find a greater difference, although the prevailing pine tree in both forests is the slash-pine, Pinus caribaea Morelet.* Two low palms are found beneath the pine trees on the east coast. They are, Serenoa serrulata (Michx.) Hook., the saw-palmetto, which with a long thick surface-growing, or underground rhizome, either grows in circular clumps, or else forms an extensive, almost exclusive, growth with leaves rising .6 to 1 meter above the rocky soil surface. It is found in two forms, the glaucous-leaved form and the form with bright-green leaves. It is less widely distributed on the west coast. Confined to the east coast is a low palm tree which first makes its appearance about the Miami River. Here it grows about 1.5 m. tall or less. As the extreme southern portion of the pineland is approached it reaches a greater height of 2 to 3 meters. It is the silver-palm, Coccothrinax argentea (Lodd.) Sarg., with silvery, flabellate leaf blades and purple-black drupaceous fruits (Plate II, Fig. 3). On Big Pine Key and on the other Florida keys, in the Bahamas, and in Cuba, it becomes a tree reaching a height of 8 meters. Its low stature on the mainland may be due to its reaching the frost limit, while on the islands where frosts are unknown and where ameliorating ocean breezes blow, it grows to a much larger size. It is a handsome palm, whether low or tall, and is a striking feature of the forest where found. It was not seen on the west coast.

The waxberry, Myrica cerifera L., was collected in the pine forest at Miami and Ft. Myers. It is a round-headed shrub with dark-green, fragrant

* In the accompanying description, the following letters will be used to designate the locality where the plants mentioned in the description were collected by me. M. = Miami; H. = Homestead; S. = Samville; F. = Ft. Myers; S.F. = South of Ft. Myers.

leaves and clustered, waxy berries. It is associated with a low oak, Quercus pumila Walt. (M.), on the east coast and on the west coast with Quercus minima (Sarg.) Small (F.) and Quercus myrtifolia Willd. (F.), sometimes 6 meters (20 feet tall). Quercus myrtifolia Willd. is a much-branched evergreen shrub and its acorns mature the second year, while the fruits of Quercus pumila Walt. mature the first year. Quercus minima (Sarg.) Small has persistent leaves. The gopher-apple, Geobalanus oblongifolius (Michx.) Small, with underground stems and ovoid drupes, occurs in the forests at Miami and Ft. Myers. Several ericaceous shrubs suggest the pine barrens of New Jersey. They are Vaccinium nitidum Andr. (M.), Vaccinium myrsinites Lam. (S. F.), Gaylussacia dumosa (Andr.) T. & G. (S.) found in New Jersey, Xolisma fruticosa (Michx.) Nash (S. F.) and Bejaria racemosa Vent. Vaccinium nitidum Andr. grows about a foot high and has small, almost sessile, pointed leaves and grayish bark, while Vaccinium myrsinites Lam. is a low much-branched shrub with box-like leaves in fruit June 6, 1912. Xolisma fruticosa (Michx.) Nash., in flower on June 6, has leathery, rusty-looking leaves. The evergreen shrub, Bejaria racemosa Vent., was gay with its glutinous white corollas with narrow spatulate petals. Before leaving Florida at the end of June, it had begun to fruit. A celastraceous shrub, Crossopetalum floridanum Gardner (=Rhacoma ilicifolia (Poir.) Trelease), has a deeply penetrating tap-root and spreading almost prostrate branches with holly-like leaves. Other low shrubs are Byrsonima lucida (Sw.) DC. (H.), Asimina reticulata Shuttlew. (S.), Croton Fergusonii Small (H.), Rhus obtusifolia Small, Rhus toxiferum (L. H.), Hypericum aspalathoides Willd. (S.), Ascyrum tetrapetalum (Lam.) Vail, Tetrazygia bicolor (Mill.) Cogn. (H.), Icacorea paniculata (Nutt.) Sudw., Guettarda scabra Vent (H.), Lantana depressa Small (H.), L. involucrata L. (M.), Callicarpa americana L. (F.), and Ximenia americana L. The greenbriar, Smilax Beyrichii Kunth, is a liane, found commonly near Ft. Myers. At the western extension of the east coast oölitic limestone formation, Long Key in the Everglades is remarkable, according to Small, for a number of shrubs found beneath the dominant slash-pine trees. Among these shrubs may be mentioned Torrubia longifolia (Heimerl.) Britton, Ilex Krugiana Loesil, Exothea paniculata (Juss.) Radlk., Jacquinia keyensis Mez., Icacorea paniculata (Nutt.) Sudw., Dipholis salicifolia (L.) A. DC. (Plate IV).

Contrasted with the undergrowth of the pine forests of the mainland, we

have that of Big Pine Key, one of the Lower keys, on which in similar oölitic limestone as at Miami, according to the collections of Small, grow three palms *Coccothrinax argentea (Lodd.) Sarg., *Serenoa serrulata (Michx.) Hook and Thrinax microcarpa Sarg., together with such plants as Smilax havanesis Jacq., Pisonia rotundata Griseb., Cassia bahamensis Mill., Vachellia Farnesiana (L.) Wright & Arn., Leucaena glauca (L.) Benth, *Icthyomethia piscipula (L.) A. Hitchc., Croton linearis Jacq., *Byrsonima lucida (Sw.) DC., *Jacquinia keyensis Mez., Anamomis longipes (Berg.) Britton, Solanum Blodgetii Chapm., Lantana odorata L., which represents L. involucrata L., L. depressa Small of the mainland and *Ximenia americana L.

The herbaceous third layer of the slash-pine forest includes such ferns as Ornithopteris (Anemia) adiantifolia (L.) Bernh. (M., H. Big Pine Key), Pteridium caudatum (L.) Maxon (M., H.), Pteridium aquilinum (L.) Kuhn (F.) and Pteris longifolia L. (H.). The coontie, Zamia floridana DC. is a cycadaceous plant extremely common in the Miami pineland (Plate IV), where it was gathered by the Seminole Indians for the starch contained in its fleshy, erect, subterranean stems, that penetrate into the pockets of limestone soil. The plants with compound, spreading, pinnate leaves, resembling ferns and palms, are diœcious. The staminate cones with scales bearing several pollen sacs are deciduous. The ovulate cones with two, or more, ovules to each scale persist until the seeds are ripe. The leafless parasite, Cassytha filiformis L., stretches from herb to herb and binds them together with its yellow, cord-like stems. The herbaceous plants, which are rarely over 60 to 80 centimeters tall form in some localities a complete cover to the forest floor together with the plants of the fourth layer and the trailing, or prostrate, herbs, such as: Dolicholus Michauxii Vail (M.) Euphorbia (Chamaesyce) deltoidea Engelm (M.). In other places the ground flora is scattered, but in all cases, the taller, stronger plants are almost invariably rooted in the small pockets of the oölitic limestone. On the west coast, where the masses of limestone are mantled by sand, a more even distribution of the herbs is possible. As the number of perennial and annual herbs found in the pine forest is considerable, they will be arranged in several columns and the most important species of these lists will be considered as to their structure and the position that they occupy in the slash-pine formation. These lists are based on plants collected by the writer on three trips to South Florida and preserved in the herbaria of

*Those found also in the slash-pine forest of the mainland according to my collections are marked with an asterisk.

PLATE IV

Pine forest of Pinus caribaea, saw-palmettos and coontie, one mile west of Miami, December 27, 1910. Original.

the University of Pennsylvania, Academy of Natural Sciences of Philadelphia, New York Botanical Garden, and U. S. National Museum at Washington, D. C. Another list was obtained by a consultation of the herbarium sheets of plants in the Herbarium of the New York Botanical Garden. The writer felt tempted to utilize the "Flora of Miami" (1913) by Small to complete his lists, but the student is referred to that book as a complete, descriptive manual of the region from the systematic standpoint. The names of the perennial herbs are printed in Roman letters and the annuals in italics, while the number affixed indicates the forest layer to which the plant belongs, whether third, or fourth layers. As the shrubs and trees have been treated in a previous description, they are not included in the lists. The species found on Little Pine Key, but included in the Big Pine Key list are marked with an asterisk. The twining, or trailing plants are marked with a dagger (†) and the questionable annual, or perennial species are indicated with a question mark(?).

REPRESENTATIVE PLANTS OF THE EAST COAST PINELANDS

Miami Region	Homestead Region	Big Pine Key
3. Ornithopteris (Anemia) adiantifolia (L.) Bernh.	3. Ornithopteris (Anemia) adiantifolia (L.) Bernh.	3. Ornithopteris (Anemia) adiantifolia (L.) Bernh.
3. Pteridium caudatum (L.) Maxon.	3. Pteridium caudatum (L.) Maxon.	3. Aletris bracteata Northrop.
3. Zamia floridana DC.	3. Pteris longifolia L.	4. Sisyrinchium flagellum Bickn
3. *Aldenella* (*Polanisia*) *tenuifolia* (T. & G.) Greene.	3. Smilax havanensis Jacq.	Bletia purpurea (Lam.) DC.
4. Piriqueta caroliniana (Walt.) Urb.	4. Petalostemon carneus Michx.	3. Chamaecrista grammica (Spreng.) Pollard.
4. *Polygala corallicola Small.*	4. Bradburya virginiana (L.) Kuntze.	3. Chamaecrista Simpsonii Pollard.
3. Amorpha herbacea Walt.	4. *Chamaesyce pinetorum* Small (?).	3. Galactia spiciformis T. & G.†
4. Crotalaria pumila Ortega†	3. Echites umbellata Jacq. †	3. Crotalaria Purshii DC.
4. Dolicholus Michauxii Vail.	3. Physalis angustifolia Nutt.	3. *Cathartolinum arenicola* Small (?)
4. Euphorbia (Chamaesyce) deltoidea Engelm.	3. Jacquemontia Curtissii Peter.	4. *Polygala corallicola* Small.
4. Euphorbia (Tithymalopsis) polyphylla Engelm.	3. *Agalinis* (*Gerardia*) *Plukenetii* (Ell.) Raf.	3. Phyllanthus pentaphyllus C. Wright.
Cassytha filiformis L. †	3. Calophanes angusta A. Gray.	4. *Chamaesyce chiogenes* Small.
4. Jacquemontia Curtissii Peter	3. *Chiococca pinetorum* Britton † (?)	3. *Samolus ebracteatus H. B. K.* (?)
3. Asclepias Rolfsii Britton.	3. Rhabdadenia corallicola Small †	Echites umbellata Jacq.
3*. Pycnothymus rigidus (Bart.) Small.	4. *Scutellaria cubensis* A. Rich.	Metastelma Blodgettii A. Gray †
3. *Actinospermum angustifolium* (Pursh) T. & G.	4. *Houstonia filifolia* (A. Gray) Small.	4. *Jacquemontia pentantha* (Jacq.) G. Don.
3. Eupatorium compositifolium Walt.	3. Lacinaria tenuifolia (Nutt.) Kuntze.	4. *Houstonia filifolia* (A. Gray) Small.
3. *Flaveria linearis Lag.*	3. Solidago tortifolia Ell.	4*. Ernodea angusta Small †
3. Leptilon canadensis (L.) Britton.		3. *Chrysopsis Tracyi* Small.
		3. Borreria podocephala DC.
		3. *Pterocaulon undulatum* (Walt.) C. Mohr.
		3. Borrichia arborescens (L.) DC.
		3. *Carduus pinetorum* Small (?)

REPRESENTATIVE PLANTS OF THE WEST COAST PINELANDS*

Ft. Myers, Pineland. S.—Samville	Pineland, South of Ft. Myers
3. Pteridium aquilinum (L.) Kuhn.	3. Andropogon longiberbis Hack.
3. Paspalum longepedunculatum Le Conte.	3. Aristida Chapmaniana Nash.
3. Aristida Chapmaniana Nash.	4. Panicum erectifolium Nash.
3. Aristida stricta Michx.	3. Rhynchospora perplexa Britton.
4. Cyperus cylindricus (Ell.) Britton.	3. Juncus megacephalus M. A. Curtis
3. Rhynchospora plumosa Ell.	Xyris Elliottii Chapm.
4. Lachnocaulon glabrum Körn.	4. Eriocaulon decangulare L.
4. Syngonanthus flavidulus (Michx.) Ruhl.	4. Lachnocaulon glabrum Körn.
4. *Cuthbertia graminea* Small (S.)	4. Aletris aurea Walt.
3. Juncus aristulatus Michx.	4. Oxytria albiflora (Raf.) Pollard.
4. *Commelina angustifolia* Michx. (S.)	4. Gymnadeniopsis nivea (Nutt.) Rydb.
3. *Chamaecrista brachiata* Pollard (?)	4. *Ibidium laciniatum* (Small) House (?)
3. Indigofera caroliniana Walt.	Limodorum multiflorum (Lindl.) Mohr.
3. Cracca spicata (Walt.) Kuntze.	4. *Polygala grandiflora* Walt.
3. *Meibomia rhombifolia* (Ell.) Vail.	4. *Polygala ramosa* Ell. (Biennial).
4. *Polygala nana* (Michx.) DC.	4. *Ludwigia linifolia* Poir (?)
3. *Gaura simulans* Small.	4. *Cynoctonum sessilifolium* (Walt.) G. F. Gmel.
4. *Sabbatia campanulata* Britton.	3. Eryngium synchaetum (A. Gray) Rose.
4. Asclepiodora Feayi Chapm.	3. Asclepias lanceolata Walt.
4. Calonyction (Ipomœa) aculeatus (L.) House.	3. *Sabbatia dodecandra* (L.) B. S. P.
3*. Pycnothymus rigidus (Bart.) Small.	*Sabbatia grandiflora* (A. Gray) Small.
4. *Sophronanthe hispida* Benth.	3. Physostegia denticulata (Ait.) Britton.
3. Buchnera elongata Sw.	4. *Coreopsis Leavenworthii* T. & G.
4. Stenandrium floridanum (A. Gray) Small (S.)	3. Eupatorium recurvans Small.
3. Pterocaulon pycnostachyon (Michx.) Ell.	3. Hyptis radiata Willd.
3. Solidago angustifolia Ell. (S.)	3. Solidago angustifolia Ell.

The following is a list of the grasses and sedges noted in the Herbarium of the New York Botanical Garden, as occurring in the pineland of the oölitic limestone of the east coast of southern Florida. The numbers, as in the preceding list, refer to the forest layer to which each species belong.

LIST OF PINELAND GRASSES

3. Andropogon tenuispatheus Nash.	5. Eustachys petraea (Sw.) Desv.
3. Andropogon Tracyi Nash.	4. Gymnopogon ambiguus (Michx.) B. S. P.
3. Aristida Chapmaniana Nash.	3. Hackelochloa granularis (L.) Kuntze.
3. Aristida stricta Michx.	4. Heteropogon contortus (L.) Beauv.
4. Cenchrus gracillimus Nash.	4. Panicum ciliiferum Nash.
3. Chaetochloa corrugata parviflora (Poir) St. M.	3. Panicum commutatum R. & S.
4. Dactyloctenium aegypticum (L.) Willd.	4. Panicum glabrifolium Nash.
3. Diplachne dubia (H. B. K.) Benth.	4. Panicum Nashianum Scribn.
3. Echinochloa crus-galli (L.) Beauv.	4. Panicum polycaulon Nash.
4. Eragrostis ciliaris (L.) Link.	3. Panicum virgatum L.
3. Eragrostis Elliottii S. Wats.	3. Paspalum caespitosum Fluegge.
4. Eragrostis plumosa Link.	3. Paspalum Simpsonii Nash.
3. Erianthus saccharoides Michx.	3. Sorghastrum secundatum (Ell.) Nash.
3. Eriochloa Michauxii (R. & S.) A. Hitchc.	3. Syntherisma Simpsonii (Vasey) Nash.

* For additional plants of the Ft. Myers neighborhood consult, *Hitchcock, A. S.:* A list of plants collected in Lee County, Florida. Proc. Iowa Acad. Sci. 9: 189–225, 1902.

LIST OF PINELAND SEDGES

4. Cyperus compressus L.	3. Rhynchospora Cymosa Ell.
3. Cyperus haspan L.	4. Rhynchospora divergens Curtis.
3. Cyperus Martindalei Britton.	3. Rhynchospora Grayi Kunth.
4. Cyperus Pollardi Britton.	3. Rhynchospora stipitata Chapm.
4. Dichromena floridensis Britton.	3. Scleria ciliata Michx.
4. Dichromena latifolia Baldw.	4. Scleria verticillata Muhl.
4. Fuirena scirpoidea Michx.	4. Stenophyllus Carteri Britton.

These lists show the character of the ground flora of the Slash-Pine Formation in southern peninsular Florida. It should be emphasized that these species rarely form pure associations, but they are scattered over the forest floor, a species here and another there. The surface soil is fairly well covered with plants, so that at a distance it seems completely covered with annual and perennial herbs, but a close inspection shows that in some cases the plants are widely spaced and separated by the fragments of limestone, or by stretches of bare sand and apparently in open formation. When one considers, however, the possible places where plants can grow between the rocks, the open character of the growth is due to the restrictions of soil room. In other places, the ground flora is much denser and the formation may be considered to be closed.

Climatic Factors.—The rocky soil of these pine forests is well suited to the growth of the citrous fruits, notably the grape-fruit, Citrus decumana Murr. and the orange, Citrus aurantium L. In some cases, it is necessary to blast a hole with dynamite before setting out these fruit trees. Under ordinary conditions of weather, the soil is porous and the water which falls as rain is rapidly lost by percolation through the sand and by the limestone holes to the underground channels. During the dry season, the plants are under essentially xerophytic conditions and this fact was emphasized in the field notes of the writer during his first and second visits to the peninsula. The slash-pine is structurally a xerophyte and many of the other plants are possessed of xerophytic structures. Notwithstanding the fact that the plants are adapted to meet the conditions of a porous soil, and a high evaporation rate, yet there are seasons when torrential rains fall, when even the soil of the driest pine forest may be submerged with water for a shorter, or a longer, period. This fact was forced home on the third visit to Florida in June, 1912, when for seven or eight days without much cessation it rained almost continuously until 17 inches of rain had fallen. The pine woods on the west coast outside of the

highest portions were entirely under water. On a drive from Ft. Myers to Six Mile Cypress, 13 kms. (8 miles) south of that town, the horses waded the entire distance in 30 to 45 cms. of water. The plants of the fourth layer were entirely submerged and those of the third layer partially so. Many of the plants were collected with open flowers entirely beneath the surface of the clear rain water. There are times, therefore, when the soil of the pineland for several weeks at a time may have a surfeit of water. That the wide distribution of many of the typic pine forest species is due to water rather than to other agents, such as winds and animals, is probable. Such floods rarely have the disastrous effects on the soil surface that they would have in a country of more considerable elevation and rapid run-off.

The movement of water in South Florida after such an inundation, except in the larger rivers where there is a considerable current, is never rapid. The surplus water gradually drains away along old and well established drainage channels and the remainder passes rapidly from the surface soil into the underground channels by percolation. It does not take long, therefore, for the country to dry up, but in this process with hot suns the surface may steam for several days. The effect of this steaming operation on plants has never been investigated, nor has the effect of the rapid alternation from dry to wet and wet to dry. That the xerophytic structure may be induced by these factors, as well as those of dry soil, intense insolation, etc., is possible, but in the absence of instrumental, or experimental, proof, one cannot be dogmatic. That the formation of flowers and fruits is influenced by such extreme flooding can be demonstrated. If the flowers are submerged at the critical period of pollination, no fruits will be formed. If the submergence occurs when the flower buds are ready to open, such an annual occurrence may be arrested, or entirely stopped. If the inundation comes when the green fruits are beginning to ripen, such a process may be inhibited completely. As in other regions, it is the critical periods of the climate and environment, which test the efficiency of the adaptations of plants, and it is these conditions, which control the successful establishment of plants in different parts of the world. Many plants from other parts of the country make a start in South Florida, but the porous soil, the winter droughts, the heavy rainfall of summer and autumn, the winds, the occasional dry hurricanes and the occasional inundations are limiting factors to many of the new forms introduced into the region and they fail of establishment.

The rainfall at Miami, according to the records of the U. S. Weather Bureau, has been for a period of thirteen years, as follows:

AVERAGE MONTHLY RAINFALL

Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	Annual
4	2.5	3.1	3.5	4.5	8.2	7.0	5.4	9.1	7.1	2.3	1.6	58.3
AVERAGE NUMBER OF RAINY DAYS												
4	3	4	4	4	5	8	7	7	7	2	2	65

Although the rainfall equals in quantity that of many other regions, yet in South Florida, as seen from the figures above, it is unevenly distributed throughout the year. The summer season is wet, the winters are usually clear and very dry. The conditions then are droughty. During the heaviest rainfall of summer, tender crops are beaten to the ground by the pelting force of the wind-blown rain, and a hard shower followed by a hot sun does considerable mischief. Another ecologic factor of considerable importance in South Florida is the wind. The prevailing winds are from the east and despite the fact that they blow from the ocean, they are dry winds. Occasional dry hurricanes blow from the south and tender vegetation is blackened and parched. The effect of the dry hurricane is similar to the desert sirocco of the Mediterranean region. The influence of these several factors accounts for the xerophytism of many South Florida plants.

Frost is another inhibiting factor. Occasional frosts of short duration visit the extreme southern end of Florida, so that tender plants are injured here and there. But these slight touches of frost in winter and the cool nights with a temperature occasionally near the frost point hardly influence the native vegetation of the region. The following is a table of the lowest temperatures in degrees Fahrenheit on record at Miami, interesting, especially as to winter conditions:

Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.
35°	29°	39°	46°	52°	65°	69°	60°	62°	54°	38°	37°

We have noted previously that the silver palm, Coccothrinax argentea (Plate II, Fig. 3) near Miami is about 1 meter tall, but farther south near Home-

stead, it reaches a height of 2 to 3 m. and on the keys of Florida, as on Big Pine Key, it becomes a good-sized tree. This variation in size is attributed to the influence of the low night temperature in winter and the occasional frost. That these factors, which influence the height of the silver palm, and its northern range, are also active as limiting factors in the distribution of many tropic species is probably true, but in the absence of experimental data, it is perhaps better to advance this view of climatic influence as a provisional hypothesis.

LONG-LEAF PINE (PINUS PALUSTRIS MILL.) FORMATION

This formation south of the 27° 30′ north latitude is a continuation, or southern lobe, of an extensive region called in Harper's report on peat the South Florida Flatwoods; and in the Tenth Census Report on Cotton Production by Dr. Eugene A. Smith (VI: 200 (1880) with map opposite page 187) the Long-leaf Pine Region. This region consists of rolling pineland and pine flats, or flatwoods. The rolling pinelands occupy rolling, or gently undulating country sufficiently elevated to secure good drainage. The whole area thus included is about 15,120 square miles. The pine flats, or flatwoods region, follows the direction of the coast margining the rolling pineland by a strip of country of greater, or less width, where the land is low, flat, or badly drained. This region embraces an area about 11,250 square miles in extent. Beside this belt, there is a tract of elevated, flat, wet land on the divide between the Atlantic Ocean and the Gulf of Mexico, which comprises another 2,280 square miles, making for the flatwoods region a total of 13,530 square miles, so that altogether the long-leaf pine, Pinus palustris Mill., covers 15,120+13,530=28,650 square miles of country.

As far as this vast region of pineland concerns this monograph, it is comprised in the counties of Polk, Manatee, DeSoto and Lee. The more or less sandy soil of the flatwoods is usually underlaid by a clay substratum, or a densely packed sand, which is impervious, and this together with the flat surface prevents proper drainage, so that swamps are associated with flatwoods. Throughout the long-leaf pine region, pine barrens occupy the poorer classes of soil. The growth upon these is mostly long-leaf pine, black-jack oak, scrubby oaks of other species. In the flat pine barrens saw-palmetto and gallberry bushes are common. "While the undergrowth of shrubs in the

barrens is sometimes scarce, and often wanting entirely, the herbaceous undergrowth is rich and varied, embracing nearly half of the flora of the state. In most pine barrens slight sinks, or basins, in the surface [see map], which are filled with water in wet seasons and are moist at all times, are of frequent occurrence, and these places have a large and characteristic flora. Where the shrubby undergrowth is scanty, or wanting, one can see for great distances between the straight trunks of the pines, and over the gently undulating surface a wagon may be driven for miles in any direction without need of following any beaten track."

The prevailing and dominant pine tree is the long-leaf pine, Pinus palustris Mill., which grows to a noble size, yields a useful timber and is tapped for turpentine. Pinus palustris Mill. differs from Pinus caribaea Morelet in a number of important characters tabulated below:

Pinus palustris Mill.	Pinus caribæa Morelet
Maximum height 40 meters.	Maximum height 35 meters.
Bark of scaly plates	Bark flat, irregular plates.
Scales light, yellowish-brown.	Scales reddish-brown.
Leaves three in a sheath.	Leaves 2 or 3 in a sheath.
Leaves 20-40 cm. long.	Leaves 18-30 cm. long.
Cone scales with recurved spine.	Cone scales armed with a small straight spine.
Cones 16–25 cm. long.	Cones 10-14 cm. long.

Nash* sketches the vegetation of the high pineland of Lake County north of the region visited by me. His account may be used for comparison with what observations the writer has to present of a region further south. Nash states that the trees have perfectly straight trunks, rising to a height of 15–22 m. (50 to 75 feet), the branches near the top. Associated with the pines are two oaks Quercus Catesbaei Michx. and Q. cinerea Michx., the former with shining, green, deeply cut leaves, the latter with narrow, entire grayish-green foliage. Several leguminous herbs are prominent, viz., Chapmania floridana T. & G., Aeschynomene viscidula Michx., Morongia angustata (T. & G.) Britton, Dolicholus (Rhynchosia) cinereus (Nash) Vail., Crotalaria Purshii DC., Cracca ambigua (M. A. Curtis) Kuntze and C. chrysophylla (Pursh.) Kuntze. Among the more frequent compositous herbs are Berlandiera subacaulis Nutt., Pterocaulon undulatum (Walt.) Ell., Carduus spinosissimus Elliottii (T. & G.) Porter, Lygodesmia aphylla (Nutt.) DC., Vernonia an-

* *Nash, George V.:* Notes on Some Florida Plants. Bulletin Torrey Botanical Club 22: 142–143, Apr., 1895.

gustifolia Michx., Hieracium megacephalum Nash, and Helianthella grandiflora T. & G. and such grasses as Aristida stricta Michx., Andropogon argyraeus Schult., A. longiberbis Hack. All the herbaceous plants have large underground parts, tubers, or thick roots, thus Commelina angustifolia Michx. has an immense fascicle of horizontally spreading roots. Tradescantia has a similar root system, while Helianthella grandiflora T. & G. has an oblong tuber buried 15 to 20 cms. deep with a horizontal stem, which rises obliquely upward. Such plants withstand the destructive action of forest fires. Other plants of the long-leaf pine forest are Asclepias humistrata Walt., Asimina pygmaea (Barts.) A. Gray, Aldenella tenuifolia (T. & G.) Greene, Stillingia sylvatica L., Croton argyranthemus Michx., Cnidoscolus stimulosus (Michx.) A. Gray, Eriogonum floridanum Small., E. tomentosum Michx., Portulaca pilosa L., Ceanothus microphyllus Michx. and Piriqueta caroliniana (Walt.) Urb.

My field notes, as they concern the territorial limits of this monograph, begin at Bartow in Polk County. Here Pinus palustris Mill. forms pure forest. The trees are draped with festoons of the Spanish-moss, Dendropogon (Tillandsia) usneoides (L.) Raf., which peculiarity of selecting the pine trees seems to prevail throughout the pine region of the west coast. The pineland alternates with hammock-land, branch swamps and sclerophyllous scrub with rounded clumps of saw-palmetto. The saw-palmetto, Serenoa serrulata (Michx.) Hook. is the prevailing undergrowth in the long-leaf pine formation, which continues south past Homeland, Ft. Meade to Torrey, where the pine forest is characterized by the presence of scattered oaks. Near Wauchula are elevated sandy hills with long-leaf pine, live oaks and saw palmettos. An open prairie occurs at Zolfo succeeded by open, pure growths of Pinus palustris. This type of country continues to Brownsville, where is pure white sand, the pine forest is filled with scattered oaks with the associated undergrowing saw-palmetto and wire-grass, probably Aristida stricta Michx. Open pine flatwoods are found about Arcadia, Nocatee and Ft. Ogden. At Ft. Ogden, the woods were bright with the flowers of the he-huckleberry or fly-catcher, Bejaria racemosa Vent., a shrub about 2 feet tall, associated with Callicarpa americana L. and Xolisma fruticosa (Michx.) Nash. The long-leaf pine forest at Morganton blends with the salt marshes of Peace River and Charlotte Harbor, where the outer edge of the pine forest between it and the salt marsh is occupied by the palmetto, Sabal palmetto (Walt.) R. & S. This in turn alternates with pine savannas, which are seen as Cleveland is approached. Here the undergrowth consists of

he-huckleberry, Bejaria racemosa Vent. and coontie, Zamia floridana DC. The tension line is very sharply drawn between the salt marsh and the saw-palmetto land with a few scattered pines. A difference of 30 cm. in level will make a difference in the vegetation. The pure forest of long-leaf pine, Pinus palustris Mill., begins to give way to a mixed forest of long-leaf pine and slash-pine, Pinus caribaea Morelet at Punta Gorda. South of this station, on Charlotte Harbor, the slash-pine becomes more prominent in the forest until it replaces the long-leaf pine almost entirely in the forest, when the Caloosahatchee River is reached, but the forest north of that river is restricted in width by its division into parts by pine savannas, swamps, salt marshes, and wet prairies. Scattered growths of long-leaf pines, Pinus palustris Mill., continue south of the Caloosahatchee River into Lee County on the authority of J. A. Davison, an engineer, as far as Surveyor's Creek, and the tree has been reported at Henderson's Creek, but it is not an important element of the forest, which consists of the slash-pine, Pinus caribaea Morelet and associated species. The Caloosahatchee River may be taken as the southern limit of the main forest of the long-leaf pine.

BANANA HOLE ASSOCIATIONS

The banana holes, so called because dwarf bananas have been raised in them, are limestone sinks, or pot-holes (Plate III, Figs. 1 and 2). The presence or absence of water is conditioned by the relative rate of evaporation, on the water-table, and on the season of the year. When the rains are heavy, the drainage of the adjoining pineland is into these limestone depressions, while in light rains, the water finds its way through the porous oölitic limestone rock into underground channels of drainage. These banana holes have originated as shallow depressions in the limestone rock and through the solvent action of rain water containing carbon dioxide, humic acid and various organic acids, the soft lime rock has been gradually eaten away until no oölitic limestone is left in the holes which communicate with underground solution channels formed coincidently with superficial erosion. Next to the surface, bristling with irregular, pointed projections, the most striking feature of the Biscayne pineland south of Miami is the presence of innumerable holes and hollows, three decimeters to one meter deep and a meter to fifty meters across. A few of these hollows may owe their origin to original conditions of deposition, some may be due to upheaval of rocks by trees uprooted by the wind, while

others have been formed by gradual solution and by the falling of roofs of subterranean water courses. Few of the holes are large enough to be termed sinks. The vertically walled banana holes extending down to permanent water level form natural wells, the shallow hollows are best termed pot-holes. G. C. Matson and F. G. Clapp* of the Florida Survey, estimate that the rate of solution in the limestone section of central Florida is about 400 tons per square mile annually. If evenly distributed, this would lower the surface of the limestone about three decimeters in five or six thousand years.

The soil which fills these rock basins is a sandy loam and rich in organic matter owing to the collection of vegetal material formed partially under standing water. The edge of these sinks may be a rock rim with vertical sides, or it may blend by gradual slope with the rock surface of the surrounding pineland. These depressions have been formed probably in irregular areas of softer oölite which, less resistant to the solvent action of rain water, has been removed by gradual solution. These pot-holes in South Florida with their characteristic vegetation suggest the limestone sinks in Bermuda, which are filled with a vegetation quite distinct from the cedar-covered hillsides. The "Cockpit Country" in Jamaica is a region of limestone sinks, but in a mountainous country and on a far grander scale.

Ecologic Considerations.—It is noteworthy that a slight difference of elevation makes an entire difference in the vegetation of South Florida. A difference of twenty to forty centimeters may mean a change in the plants which enter into any particular plant formation. Here under practically the same climatic conditions we find plant formations which owe their character to the controlling edaphic, or soil conditions. Here on a scale not found elsewhere in North America, the ecologist can study the influence of varying amounts of soil water on the native vegetation of the country.

The banana holes (Plate III, Figs. 1 and 2), as depressions in the flat woods, owe their ecologic character to their size, the character of their soil, richer or poorer in humus and the presence, or absence, of standing water during the whole, or a part of the year. In wet weather some of these pot-holes are filled with water, but during dry weather, the water disappears by seepage, or by rapid evaporation. The occupancy of these banana holes by the migration of plants, is purely fortuitous,† but the survival of any one species,

* *Matson, G. C., and Clapp, F. G.:* Second Annual Report, Florida State Geological Survey, 1908–09: 34; Cf. *Geikie, Archibald:* Text Book of Geology (third edit.): 344.

† See what follows under heading "Means of Distribution."

or groups of species, is conditioned solely by amount of space, light and edaphic influences. A very slight difference in the soil, drainage, depth below the general surface of the pineland, amount of soil, quantity of standing water and amount of light which penetrates between the pine trees makes a striking difference in the composition of the vegetation of these banana holes. That such slight differences of environmental conditions influence the character of the vegetation is demonstrated by that of the snow patches found in the European Alps. These snow patches are, according to C. Schröter,* gently inclined flat, or concave spots that occur in the Alps and are saturated with water from melted snow. If they exist as depressions filled with snow for a long time, then there is deposited thick, black humus which owes its origin to the snow. For this carries down from the air a quantity of organic dust, wind-blown particles gather here, and the snow is thus made a catch-all for such extraneous bodies. This habitat is characterized by lowness of temperature, abundance of humus and permanent saturation of the soil. The community of plants settling upon it in Switzerland is extremely constant.

Similarly the limestone sinks in South Florida receive a large amount of material washed into them from the surrounding pineland. These materials consist of sand, and minerals leached out of the exposed surface oölite, while in addition leaf mould, small branches, pine cones, etc., are swept into the pot-holes and collect like the material does in the vortex of water which rushes from a paved street of a city down into a grated culvert provided to catch the surface run-off. Then too the herbaceous vegetation of such sinks is protected in the bottom from sharp winds which visit South Florida, and from the too direct rays of sunlight. Such concave spots are usually moister, so that filmy ferns† (Hymenophyllaceæ) are found growing along their edges, while epiphytic orchids, ferns and bromeliads live attached to the trees above. Many shade-loving plants find a suitable habitat here, for the sunlight, first cut off by the surrounding pine trees, must pass the tree and shrubby growth which fills the banana holes and receive an amount of light conditioned by the depth of the well below the general surface of the pineland.

Origin of Banana Holes and Hammocks.—As the banana holes exist in all sizes from those which can be jumped across to those covering one hectare, a sharp distinction cannot be drawn between the vegetation of the larger banana holes and the smaller hammocks which occur in the same region. For example

* *Warming, Eug.:* Ecology of Plants: 319. † On the authority of Ernst Bessey.

at the edge of the pineland in South Florida near Detroit were found two hammocks, one about ten ares in extent, the other occupying about one hectare. The smaller occupied a basin-shaped depression, the center of which was filled with water. The larger hammock was somewhat more elevated and level with a deep, rich soil. No sharp demarcation was found in the vegetation of the smaller hammock, which filled a sink hole, and the larger drier one.

E. A. Bessey* has advanced the theory that "Somewhere in the pine woods a few of the small shrubs, or occasional small persimmons (Diospyros virginiana L.), or other broad-leaved trees of which a few kinds are formed also in the pine woods, form a somewhat sheltered place within which the air is somewhat moister. Here owing to the increased shade, the soil does not dry out so much, as where the sun is more direct. Other trees, favored by this increased moisture of soil and air, especially the live-oak, are thus enabled to get a start. Soon more trees and shrubs appear, the conditions becoming more favorable the more numerous and larger they become. The whole space between the trees grows up to underbrush. The denser the growth becomes, and the larger the trees, the more humid is the air, while the dense shade protects the soil from drying out. Many of the plants, that in the open pine forest are small shrubs, become fair-sized trees when they encounter these more favorable conditions. The denser the growth, the more humid the air and the moister the soil, so much more fully do these and other typical hammock plants reach their full development. Soon epiphytes begin to appear, other typical hammock plants come in and we have a typical hammock." Harper† believes that the origin of a hammock in a certain area can be traced directly to the protection of that area from fires that sweep the adjacent unprotected pinelands. He says: "for the Florida hammock peninsulas, if not for all other cases referred to, the key to the situation can be expressed in a single word: Fire. On this theory it is easy to account for the origin of insular and peninsular hammocks. The absence of fire would in time allow sufficient humus from the pioneer vegetation to accumulate to give the hardwoods a start, and the latter would grow up and finally make enough shade to prevent the reproduction of the pines and other pioneer plants, which are what foresters term 'intolerant'

* *Bessey, E. A.:* The Hammocks and Everglades of Southern Florida. The Plant World 14: 271–273.

† *Harper, Roland M.:* The Relation of Climax Vegetation to Islands and Peninsulas. Bulletin Torrey Botanical Club 38: 522–523, 1911.

PLATE V

FIG. 1.

Sand-pine (rosemary) scrub with Pinus clausa (Engelm.) Vasey, saw-palmetto, Serenoa serrulata (Michx.) Hook., and in the forefront the rosemary, Ceratiola ericoides Michx., August 10, 1911, Delray, Fla. Original.

FIG. 2.

Big (Brickell) hammock south of Miami, August 12, 1911, blending with saw-palmetto vegetation. Note tall live-oaks and palmettos. Original.

and will not germinate in dense shade." Without contradicting either of these points of view, it seems to the writer that a slightly different interpretation of the facts can be made. Bessey's theory accounts for the genesis of hammocks only in part; Harper's theory for the sharp demarcation of pineland, on the one hand, and the hammocks on the other, and it accounts in part for the preservation of the moister hammock land and its climax vegetation, once the genesis of it is explained. Bessey starts with the appearance of non-coniferous species in a closed formation of pineland vegetation, but he does not explain fully how such plants were able to get a start in a closed formation in competition with the pine barren vegetation, which is a remarkably exclusive and persistent type. My theory, that the hammocks started in depressions with a sandy-loamy, perhaps marly, soil and under different edaphic conditions, explains why non-coniferous species have been able to invade the pineland and overcome the competition of well-established and exclusive pine vegetation. The broad-leaved trees and shrubs are able to get hold in the banana holes, because the different edaphic conditions of limestone, pot-hole environment have excluded the typic pine barren plants. (Plate III, Figs. 1 and 2.)

These different edaphic conditions are one of the results of the natural relations of the limestone and the surface beds of sand and loam which have been deposited over it. A central divide, or water-shed, 60 to 75 meters in elevation, is found with numerous ponds in the central part of the state between the Atlantic and Gulf drainage systems. On either side of this watershed erosion has removed the sands and partially exposed the underlying limestone, and wherever this rock, in its disintegration, affects the overlying limestone, sands and soils, the conditions are found for the formation of hammocks, which have soils that represent the interaction of sand, loam, and decomposed limestone which are marled in their formation.*

It will thus be seen that the distribution of the hammocks depends upon two factors: First the configuration of the underlying limestone, with its worn surface, its elevations and depressions, and second, the position of existing lines, or channels of drainage. After the typic species of the banana holes have become established in the depressions that are widely spread through the pineland, the subsequent course of events is much as Bessey has so lucidly described. Harper's fire theory, although perhaps applicable to

*Consult *Smith, Eugene A.:* loc. cit., p. 203.

other parts of Florida, is hardly in accord with the geographic conditions, as they are found in extreme southern Florida. Here the otherwise continuous stretch of pine timber is intersected by transverse prairies some of them a kilometer across, which are submerged during a part of the year, thus serving as a partial barrier to forest fires and Big Pine Key covered with pines and hammocks is surrounded by the ocean. According to Harper's theory, these protected areas of elevated land should be covered with hammock vegetation, but they are not. The pine trees (Pinus caribaea Morelet) are supreme with their associated undergrowth. Right in the center of this pineland, which owes its open condition to forest fires according to Harper, are the banana holes with elements of the true hammock vegetation. If the pine woods owed their floristic character to forest fires, as Harper emphasizes, then there would be no banana hole vegetation for the fire would have destroyed all such non-coniferous species.

My observations on the banana holes of South Florida seem to indicate that they have arisen by the occupancy of a limestone hollow, or depression by vegetation, which gradually filled the basin with forest litter until the presence of this rich humus resulted in the self-perpetuation of the hammock formation. They are not extensive enough to make any sweeping generalization, but from my study of the big hammock between Miami and Cocoanut Grove, I wish to propose an hypothesis as to its formation. Given an original area of exposed oölitic limestone, it is probable that such an area was not perfectly level, but was marked with larger, or smaller, concavities. Such concavities might cover two hundred and fifty-nine hectares (=one square mile) of country. The center of the basin might be only three to six decimeters below the edge of the depression with the sides sloping almost imperceptibly toward the center. Such an area would become a shallow reservoir in rainy weather and perhaps on the disappearance of the water in drier weather its soil would retain a lot of ground water. Chance seeds carried by wind and by animals falling into these saucer-like hollows would develop into broad-leaved shrubs and trees, which would soon completely fill them. The soil, although over an underground drainage depression, holds its soil water longer. This would exclude by close occupancy of the ground the pine trees, which flourish in a drier soil, because less retentive of soil-water. Soon the basin would fill with humus and the vegetal material mixing with the sand and the marl washed into the

area would soon form a sandy marl loam, which is actually the character of the soil in the big hammock south of Miami. Once mesophytic conditions are established by the enrichment of the soil through the deposit of vegetal material, the complete shading of the soil by the dense tangle of trees, lianes and other plants, would make self-perpetuative these conditions and the subsequent successions would be concerned with the broad-leaved subtropic and tropic forest vegetation. The shading of the soil and the increase in the amount of spongy humus would increase the retentivity of the soil to moisture, and in time, the surface of the hammock would be raised by plant growth above the general surface of the surrounding pineland, where the accumulation of humus is extremely slow owing to the rapid desiccation of the forest litter. Such an hypothesis probably explains the origin of other Florida hammocks beside the celebrated one near Miami.

Geographic Location of Banana Holes.—The sinks, or banana holes of South Florida, are located in the region covered by Miami oölite and especially in the district south of Rockdale, a station on the Florida East Coast Railroad, south of Miami. From Rockdale south to Homestead and Detroit, the banana holes become more frequent, but undisturbed examples are not found until after passing Naranja (Text Fig. 1), because the settlers of the region between Rockdale and Naranja have utilized all of the existing banana holes in the raising of tender plants, which have occupied the sink during the entire period of their growth, or have been transplanted to the prairie, or pineland, after they have passed the tender seedling condition. The farmers of the region use the banana holes to start their market vegetables, instead of the usual hot beds characteristic of such market gardening in the northern states. One of these banana holes at Goulds was filled with cotton. Another was occupied by growing Kaffir corn, while another was marked by the presence of a group of dwarf bananas, probably Musa Cavendishii Lambert. Much of the prairie and pine soils of the region are being used in the growth of early tomatoes for the northern market. In the north, as the tomato requires a warm soil and climate, a sunny position and long season, the plants are usually started in hot beds, or glass houses, being transferred to the open as soon as settled weather permits. In the region of Florida where banana holes are common, tomatoes are started in them, where they are protected from occasional frosts, and afterward they are transplanted for open field culture.

As the country between Naranja and Princeton was the one visited by the writer on August 18, 1911, the banana holes noted along the railroad

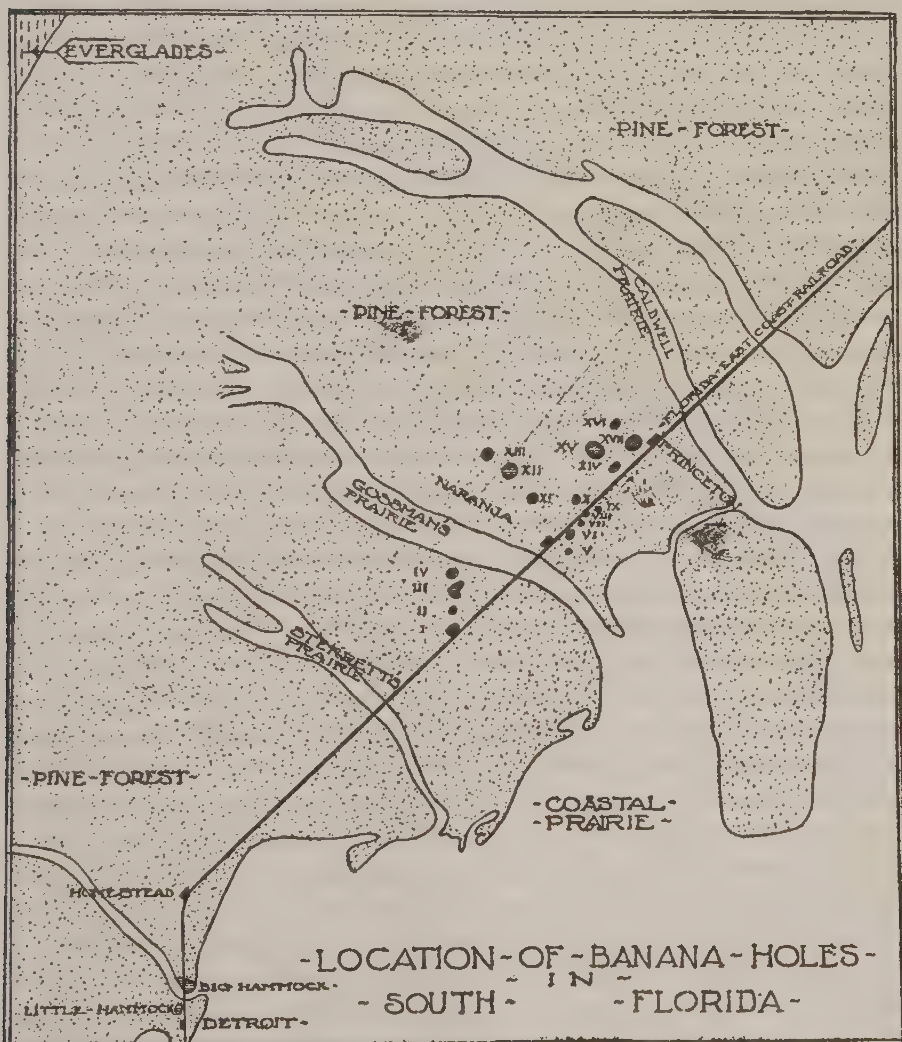

FIG. 1.

are represented in a sketch map of the region (Text Fig. 1). The line of the railroad was followed, because of the rough nature of the country traversed,

and accordingly, only hollows on either side of the railroad right-of-way were studied. Presumably, however, the holes are found in the pineland between Bay Biscayne and the Everglades. A more extended survey of them before the native vegetation is exterminated would well repay the botanist. Such investigation must be done in the next few years, as the region is being rapidly settled. In the time which was available, seventeen banana holes were studied.

Characteristic Plants of the Banana Hole Associations.—Whether to denominate the peculiar aggregation of plants which fill the banana holes as an association, or formation, in the ecologic sense has not been decided. If the term formation is used, it might be applied in two ways. Either we might include all of the widely separated banana holes in the hammock formation, as incipient hammocks, or else, we might consider them as so many distinct formations. It seems, therefore, that to call them associations would be better and a more exact use of terms than to apply the term formation to them. The vegetation of each banana hole is actually an association of plants, and as there is little similarity among the different banana holes, as to their vegetation, the term association is less misleading than that of formation.

Incidentally before describing the seventeen banana holes between Naranja and Princeton, it might be mentioned that a circular banana hole was noted from the moving train in the pine woods below Perrine. This hollow was filled with saw-grass, Cladium effusum (Sw.) Torr., and the central area occupied by the exclusive growth of saw-grass was fringed by a circle of low palmetto trees, Sabal palmetto (Walt.) R. & S. Another banana hole near Perrine was characterized by a central lagoon of water fringed by saw-grass and an outer circumarea of dwarf palmettos blending with the pine forest. This pine forest consists of an even stand of Pinus caribæa Morelet, the slash-pine. The trees stand rather far apart, frequently six to ten meters, thus forming an open sunlit forest. The tops are rather small and so do not cast much shade. The trees are so scattered that objects can be seen at a distance of eight hundred to a thousand meters. The saw-palmetto, Serenoa serrulata (Michx.) Hook. with prostrate, or underground, rhizomes, as thick as an arm, with the coontie, Zamia floridana DC., form part of the undergrowth which consists otherwise of scattered small shrubs and herbaceous plants.

The banana holes studied in the territory between Naranja and Princeton are numbered in order proceeding from the south toward the north (Text

Fig. 1). Number one occurred along the carriage road below Naranja. It was filled, on August 18, 1911, with standing water. The vegetation consisted of the custard-apple, Annona glabra L., which formed a low, stout tree, in full ripe fruit, associated with bay, Persea pubescens (Pursh) Sarg., existing as a shrub, or small tree, sometimes reaching a height of twelve meters; yaupon, Ilex cassine L., an evergreen, small tree with red berries; tall willows, Salix longipes Anders (?); dwarf palmettos, Sabal palmetto (Walt.) R. & S., and such shrubs, as buttonbush, Cephalanthus occidentalis L. in fruit, Morinda roioc L. with somewhat prostrate habit, and waxberry, Myrica cerifera L. Two vines grew, as prominent elements, namely, Vitis Munsoniana Simpson and Smilax laurifolia L. Several epiphytic tillandsias and orchids grew attached to the willow trees, while the fern, Polypodium polypodioides (L.) A. S. Hitchcock (=P. incanum Sw.) was found abundantly on trees in the depression. The mermaid-weed, Proserpinaca platycarpa Small, grew submerged in the water. The second banana hole was about five meters in diameter with steep rock edges and was filled with water. It accommodated two dwarf palmettos and several smaller ones, four to five custard-apple trees and a group of arrowleaf, Sagittaria lancifolia L., and the submerged mermaid-weed, Proserpinaca platycarpa Small. The third hollow proceeding northward was characterized by the presence of a society of the tall reed-grass, Phragmites phragmites L. Karst. together with low custard-apple trees, dwarf palmettos, Persea pubescens (Pursh) Sarg., the coral-sumach, Rhus (Metopium) toxiferum L., yaupon, Ilex cassine L., with bright-red berries, buttonbushes, Cephalanthus occidentalis L., wax-myrtle shrubs, Myrica cerifera L., a low live-oak, Quercus virginiana L., bullace-grape, Vitis Munsoniana Simpson, and Sagittaria lancifolia L. growing in the shallow water (Plate III, Fig. 1).

Banana hole four, filled with water, showed a denser, more evergreen type of vegetation consisting of the red-berried yaupon, or dahoon, Ilex cassine L., custard-apple, Annona glabra L., bay-trees, Persea pubescens (Pursh.) Sarg., palmettos, Sabal palmetto (Walt.) R. & S., cocoa-plum trees, Chrysobalanus pellocarpus G. F. W. Mey., with orbicular, leathery leaves, in flower, waxberry bushes, Myrica cerifera L., and a few dead shrubs in the center. A large Tillandsia grew attached to the cocoa-plum, while Vitis Munsoniana Simpson climbed the trees, and the mermaid-weed, Proserpinaca platycarpa Small, growing submerged, was extremely abundant (Plate III, Fig. 2). Proceeding

in a northward direction toward Princeton, a prairie was crossed to another area of pineland (Text Fig. 1). The fifth hollow, north of the prairie glade, was a small one devoted to the raising of Kaffir-corn, Sorghum halepense Pers. Number six was a water-filled pot-hole characterized by palmettos, Sabal palmetto (Walt.) R. & S., cocoa-plum trees Chrysobalanus pellocarpus G. F. W. Mey., waxberry shrubs, Myrica cerifera L. and a few epiphytic tillandsias. On a taller palmetto was found a large fern, Phlebodium aureum (L.) R. Br. (=Polypodium aureum L.) with rhizomes twining about the palmetto stem. In the water of this hole grew Sagittaria lancifolia L. and a few sedges, while the soil along the low margin at one side of the hole was trodden to mud by cattle. The seventh banana hole was an open almost treeless one filled with an even mixture of saw-grass, Cladium effusum (Sw.) Torr., and Sagittaria lancifolia L., with two low custard-apple shrubs, Annona glabra L., while the hollow adjoining was filled with a scattered growth of saw-grass, Cladium effusum (Sw.) Torr. The ninth hollow was almost completely occupied by the aquatic arrowleaf, Sagittaria lancifolia L., which with its tall vertically disposed leaves, white flowers and dark-green color formed a conspicuous contrast to the light-green undergrowth of the pineland. A few tufts of the saw-grass grew along the edges of this hole. The tenth banana hole was water filled. Here grew in association custard-apple trees, Annona glabra L., bay-trees Persea pubescens (Pursh.) Sarg., cocoa-plums, Chrysobalanus pellocarpus G. F. W. Mey., palmettos, Sabal palmetto (Walt.) R. & S., buttonbushes, Cephalanthus occidentalis L., entirely without epiphytes.

An unusual condition was found in the eleventh depression, which was of small size about a meter across. Here grew a single palmetto, Sabal palmetto (Walt.) R. & S. about two meters tall. The twelfth banana hole partially filled with water was occupied by custard-apple trees, Annona glabra L., cocoa-plum shrubs, Chrysobalanus pellocarpus G. F. W. Mey., small palmettos, Sabal palmetto (Walt.) R. & S., while epiphytic orchids grew perched upon the larger custard-apple trees. The cat-tail, Typha angustifolia L. and the arrow-leaf Sagittaria lancifolia L. grew about the bases of the trees in this hole. Banana hole number thirteen was a wet one with an open lagoon of water. Here grew custard-apple trees, cocoa-plum trees, two palmettos, very much scattered in their disposition, together with a perennial herb, Conoclinum dichotomum Chapm. growing out of the water. In the water grew Sagittaria lancifolia L., and entirely submerged, the mermaid-weed, Proserpinaca platycarpa Small,

and Isnardia natans (Ell.) Small, associated with protruding saw-grass, Cladium effusum (Sw.) Torr. The wet sink designated number fourteen was a small one filled with palmettos, cocoa-plums, custard-apples, waxberry bushes and a few sedges.

Banana hole fifteen was a middle-sized, circular depression completely fringed by dwarf palmettos, Sabal palmetto (Walt.) R. & S., and filled, except a small central lagoon, by spreading custard-apple trees, Annona glabra L., loaded with epiphytic orchids and tillandsias. The fern, Phlebodium aureum (L.) R. Br. (=Polypodium aureum L.), grew attached by its rhizomes to the palmetto, while associated with the custard-apple trees grew cocoa-plums, Chrysobalanus pellocarpus G. F. W. Mey., three meters tall and waxberry bushes, Myrica cerifera L. The water of the lagoon was characterized by the scattered growth of Sagittaria lancifolia L. This was perhaps the most beautiful and interesting of the banana holes studied by me. A few willow trees, Salix longipes Anders (?), characterized the sixteenth limestone pot-hole filled with water.

The last hole (No. 17) before reaching Princeton was much altered by fire, showing that a hot forest fire* would entirely exterminate the banana-hole plants. The original vegetation, as attested by its remains, consisted of palmettos, Sabal palmetto (Walt.) R. & S., cocoa-plums, Chrysobalanus pellocarpus G. F. W. Mey., willow, Salix longipes Anders (?), draped with the bullace-grape, Vitis Munsoniana Simpson, and the twining perennial composite, Mikania batatifolia DC., while Isnardia natans (Ell.) Small grew as the only submerged herbaceous plant.

Enumeration of the Species.—Twenty-three species are mentioned in the description of the seventeen banana holes in the two kilometers of pineland between Naranja and Princeton in South Florida. This list would be considerably augmented, if we included the several species of Tillandsia and epiphytic orchids found attached to the prevailing tree growth. Only the most conspicuous plants have been mentioned. The algæ, fungi, lichens, and mosses have been disregarded, as also the plants occurring in the big and little hammocks at Detroit. Systematically the species are arranged as follows, while the numerals indicate the particular banana hole where the species were found.

*See the views of Harper in the preceding account.

POLYPODIACEAE

Polypodium polypodioides (L.) A. S. Hitchcock (= P. incanum Sw.) I.
Phlebodium aureum (L.) R. Br. (=Polypodium aureum Sw.) VI, XV.

TYPHACEAE

Typha angustifolia L. (cat-tail) XII.

ALISMACEAE

Sagittaria lancifolia L. (arrow-leaf) II, III, VI, VII, IX, XII, XIII, XV.

GRAMINACEAE

Phragmites phragmites L. (reed-grass) III.

CYPERACEAE

Cladium effusum (Sw.) Torr. (saw-grass) VII, VIII, IX, XIII.

PALMACEAE

Sabal palmetto (Walt.) R. & S. (palmetto) I, II, III, IV, VI, X, XI, XII, XIII, XIV, XV, XVI.

BROMELIACEAE

Tillandsia (several epiphytic species) I, IV, VI, XV.

SMILACACEAE

Smilax laurifolia L. I.

ORCHIDACEAE

Several epiphytic species, I, XII, XV.

MYRICACEAE

Myrica cerifera L. (waxberry) I, III, IV, VI, XIV, XV.

SALICACEAE

Salix longipes Anders (willow) I, XVI, XVII.

FAGACEAE

Quercus virginiana L. (live-oak) III.

ANNONACEAE

Annona glabra L. (custard-apple) I, II, III, IV, VII, X, XI, XII, XIII, XIV, XV.

AMYGDALACEAE

Chrysobalanus pellocarpus G. F. W. Mey. IV, VI, X, XII, XIII, XIV, XV, XVII.

ANACARDIACEAE

Rhus toxiferum L. (=Metopium toxiferum (L.) Krug & Urb.) (coral-sumach) III.

AQUIFOLIACEAE

Ilex cassine L. (yaupon, dahoon) I, III, IV.

VITACEAE

Vitis Munsoniana Simpson (=Muscadinia Munsoniana (Simpson) Small) (grapevine) I, III, IV, XVII.

LAURACEAE

Persea pubescens (Pursh) Sarg. (bay-tree) I, III, IV, X.

ONAGRACEAE

Isnardia natans (Ell.) Small (=Ludwigia natans Ell.) XIII, XVII.

GUNNERACEAE

Proserpinaca platycarpa Small. (mermaid-weed) I, II, IV, XIII.

RUBIACEAE

Cephalanthus occidentalis L. (buttonbush) I, III, X.
Morinda roioc L. I.

COMPOSITAE

Conoclinum dichotomum Chapm. XIII.
Mikania batatifolia DC. XVII.

If we examine this list, we find that as to their abundance the species may be arranged according to the number of banana holes in which they grow: Sabal palmetto (12), Annona glabra (11), Chrysobalanus pellocarpus (8), Sagittaria lancifolia (8), Myrica cerifera (6), Persea pubescens (4), Vitis Munsoniana (4), Proserpinaca platycarpa (4), Cladium effusum (4), Ilex cassine (3), Cephalanthus occidentalis (3), Salix longipes (3), Phlebodium aureum (2), Isnardia natans (2), Polypodium polypodioides (1), Typha latifolia, Phragmites phragmites (1), Smilax laurifolia (1), Quercus virginiana (1), Rhus (Metopium) toxiferum (1), Morinda roioc (1), Conoclinum dichotomum (1), Mikania batatifolia (1).

Growth Forms.—The vegetation of the banana holes consists of several growth forms which in association give general physiognomic character to them.

Trees

Sabal palmetto
Annona glabra
Chrysobalanus pellocarpus
Persea pubescens
Ilex cassine
Salix longipes
Quercus virginiana
Rhus (Metopium) toxiferum
Morinda roioc

Shrubs

Myrica cerifera
Cephalanthus occidentalis

Lianes

Vitis Munsoniana
Mikania batatifolia
Smilax laurifolia

Epiphytes

Phlebodium aureum
Tillandsia (several species)
Orchidaceae (several species)

Rooting Aquatics

Sagittaria lancifolia
Cladium effusum
Typha angustifolia
Phragmites phragmites

Submerged Aquatics

Proserpinaca platycarpa
Isnardia natans

The pine woods, as previously described with an even stand of tall boles, allow an unbroken vista in all directions over a flat, forest floor covered by low shrubs and an occasional silver-palm, Coccothrinax argentea (Lodd.) Sarg. (Plate II, Fig. 3). The tall tree columns supporting the dark green crown of pine foliage permit a large amount of sunlight to reach the ground between the widely spaced pine trees. The vegetation of the banana holes is in strong contrast to this open, sunlit pine forest, for the continuous vista of the pine woods is broken by the clumps of broad-leaved trees and shrubs in the banana holes, wherever they stand in the line of sight. These associations are composed of monocotyledonous and dicotyledonous shrubs and trees, some of which are evergeen, loaded in some cases with epiphytes, which seize upon the available light spaces, while the remaining intervals are closed by the growth of the vines previously described. Such plants, which grow beneath the crown of the pine trees, consist of tolerant species, while the pine trees are intolerant.

In the shade of the pines and banana hole trees the moisture-loving epiphytic ferns, orchids and bromeliads grow. Altogether the dense, tangled mass of plants growing in closed association cast a dark shade which contrasts

strongly with the sunny floor of the open pine woods. The dark recesses of these small hammock patches encourage the growth of moisture-loving, lower plants, which are entirely absent from the open, well-lighted and wind-swept stretches of pine forest. And by these means the botanist can single out the areas where the banana-hole vegetation, growing under different photic and edaphic conditions, is able to exist in competition with the exclusive and persistent types of the pine-barrens.

Means of Distribution.—The plants characteristic of the banana holes (Plate III, Figs. 1 and 2) can be arranged into several groups, according to the means by which they have migrated into the pot-holes, which abound in the Biscayne pineland, south of the Miami River.

Wind Distributed

Polypodium polypodioides, spores.
Phlebodium aureum, spores.
Typha angustifolia, hair-tufted, small fruits.
Phragmites phragmites, long silky hairs in the intervals between the florets of the spikelets.
Tillandsia, hair-tufted, small seeds.
Orchidaceae, microscopic seeds, testa bladdery.
Salix longipes, hair-tufted seeds.
Conoclinum dichotomum, hairy pappus on achenes.
Mikania batatifolia, hairy pappus on achenes.

Water Distributed

Sagittaria lancifolia, seeds shining, not wetted by water, hence floating.
Cladium effusum, achenes small, with corky tips.
Annona glabra, by the light corky wood, carried by water through the pine forest.
Cephalanthus occidentalis, small fruits.
Isnardia natans, seeds small.

Animal Distributed

Sabal palmetto, drupe, avivectent.
Smilax laurifolia, berry, avivectent.
Myrica cerifera, small wax-covered nut, avivectent.
Quercus virginiana, acorn, by birds and rodents.
Annona glabra, large juicy fruit, avivectent.
Chrysobalanus pellocarpus, fleshy drupe, avivectent.
Rhus (Metopium) toxiferum, drupe, avivectent.
Ilex cassine, red fleshy drupe, avivectent.
Vitis Munsoniana, berry, avivectent.
Persea pubescens, drupe, avivectent.
Morinda roioc, syncarp.
Sagittaria lancifolia, small seeds in mud on birds' feet.
Cladium effusum, small achenes in mud on birds' feet and feathers.
Cephalanthus occidentalis, small fruit segments in mud on birds' feet.
Proserpinaca platycarpa, nut-like fruit, in mud on birds' feet.
Isnardia natans, small seeds in mud on birds' feet and feathers.

It will be noted that five of the species enumerated above have been placed as both water and animal distributed. With abundance of water, as in times of inundation, they are carried by water currents; with a less amount, or no water at all, they are probably carried by animals. A consideration of four of these plants follows. The saw-grass, Cladium effusum, has obovoid achenes, somewhat corky at the summit. The buttonbush, Cephalanthus occidentalis, has small fruits at length splitting from the base upward into two to four closed, one-seeded portions. The false loosestrife, Isnardia natans, has a many-seeded capsule, while the mermaid-weed, Proserpinaca platycarpa, has a bony, three-angled, three-seeded, nut-like fruit. Where the water is in motion, these plants, along with Sagittaria lancifolia, undoubtedly have their fruits distributed by water currents, and perhaps they have been carried from banana hole to banana hole in seasons when the pineland was flooded with water, or they have fallen to the mud of these shallow water pools and have been carried away incased in the mud on the feet, beaks, and feathers of ducks, herons, swallows, and other frequenters of such wet places.

HAMMOCK VEGETATION

The examination of the vegetation of the banana holes has suggested the possible origin of the hammocks which form such a conspicuous element in the landscapes of South Florida. The moisture content of the soil plays a most important part in the distribution of the plants. The typic everglade species are aquatic plants; the typic pineland species grow in extremely dry soil during the dry season, while the vegetation of the banana holes and hammocks is decidedly mesophytic, but the character of the hammock is conditioned upon the water content of the soil. We can distinguish, therefore, two kinds of hammocks, viz., high hammocks (Plate V, Fig. 2) and low hammocks (Plate VI, Fig. 2). The high hammocks are found under the conditions of soil and surface described in the foregoing paragraph. The low hammocks are those which occur along the margins of many lakes and streams (Plate VI, Fig. 1) and in some of the low swampy areas not connected with any running water or lakes. These low hammocks appear to have generally more sandy soil than the high hammocks.

HIGH HAMMOCK FORMATION

A hammock from the standpoint of the physiognomy of the vegetation is a group of hardwood trees, shrubs, vines, terrestrial and epiphytic herbs scattered as islands about the country, usually in a rather deep soil, rich in humus, or vegetable matter, and more retentive of water than the adjacent pineland (Plate V, Fig. 2). The growth is generally so crowded that the vines, epiphytic ferns, orchids, and bromeliads are found in every available light space. Small described a hammock which was being destroyed by the excessive development of epiphytes, which took possession of every available bit of surface until by their weight the trees were thrown to the ground. The broad leaf canopy is so thick by the interlocking of the upper branches of the trees that the shade beneath the trees is very dense and even at midday a twilight prevails beneath the dominant trees. Only those plants can exist beneath the trees that are tolerant, and the absence of a rich herbaceous undergrowth is a marked feature of the larger hammocks, and the leaf litter, which collects at times, rapidly disintegrates and the forest floor is, therefore, a remarkably clean one. The vegetation consists mainly of large trees, small trees, shrubs, lianes, and epiphytes. The hammock vegetation includes the great majority of flowering plants now known to be common to the West Indies and Florida. The area occupied by the hammocks is insignificant, as compared with that of the pineland, yet there are nearly as many species of flowering plants growing in these small areas, as there are in the vast pinelands.

In a preceding part of this paper, I have referred to the probable origin of the hammock vegetation in a way similar to that of the smaller pot-holes. That is, the broad-leaved hammock plants appear in depressions of the surface which gradually fill with an abundance of humus, so that a rich, sandy loam is formed in which this peculiar type of vegetation is perpetuated. Near Detroit, the last settlement on the eastern coast of the mainland of Florida, occur two hammocks, which according to my observations have had their origin in large depressed areas, or extensive pot-holes. The smaller one is characterized by live-oak trees, *Quercus virginiana L., with large twisted branches supporting epiphytic ferns, *Polypodium polypodioides (L.) A. S. Hitchcock, bromeliads and orchids, such as Epidendrum rigidum Jacq., associated with an evergreen tree, Dipholis salicifolia (L.) DC., palmettos, *Sabal palmetto (Walt.) R. & S., Tetrazygia bicolor Cogn., cocoa-plum,

* Indicates species common to hammocks and banana holes.

*Chrysobalanus pellocarpus G. F. W. Mey, Erythrina arborea (Chapm.) Small, Callicarpa americana L., *Myrica cerifera L., and the vines, Rhus radicans L., *Vitis Munsoniana Simpson, and Smilax sp. The center of this hammock is depressed and filled with water, forming what is called locally a 'gator hole.

The larger hammock is situated some distance north of Detroit at the edge of a transverse prairie and is about a hectare in extent. Here are large live-oak trees, *Quercus virginiana L., loaded down with such ferns as *Polypodium polypodioides (L.) A. S. Hitchcock, various species of bird's-nest-like Tillandsias (T. fasciculata Sw., T. tenuifolia L.) and such epiphytic orchids as Epidendrum cochleatum L. Associated with the oaks are the doctor-gum, *Rhus toxiferum L., with smooth bark, gumbo-limbo, Bursera simaruba (L.) Sarg., *Morinda roioc L., and smaller trees, such as Ilex Krugiana Loes., Picramnia pentandra Sw., Psychotria undata Jacq., Citharexylum villosum Jacq., sometimes seven meters tall, Guettarda scabra Vent., together with the shrubs Callicarpa americana L., marlberry, Icacorea paniculata (Nutt.) Sudw. (= Ardisia Pickeringii T. & G.), *Myrica (Morella) cerifera L. The large trees are draped with lianes, such as Virginia-creeper, Ampelopsis quinquefolia (L.) Michx., grapevine, *Vitis Munsoniana Simpson, poison-ivy, Rhus radicans L. The ground vegetation consists of the perennial herb, Cassia ligustrina L., the fern, Ornithopteris adiantifolia (L.) Bernh., with tillandsias that have broken off with tree limbs and that have become established in the rich dark soil, through which here and there the sharp projections of the limestone rock are to be seen. The twisted limbs of the large hammock trees loaded with epiphytes, the dense tangled growth of the trees, shrubs, and lianes with a rich black soil, are in sharp contrast to the tall, straight, limbless pines, which together form an open, sunlit forest with an abundant ground vegetation growing in a drier, more porous, and rockier soil, and hence, more xerophytic. The papaw, Carica papaya L., as an exotic, enters the clearings made in the edge of the hammocks. It appears in the form with slender, green stem and relatively small fruit.

The large hammock south of the Miami River, known as Brickell Hammock, is one of the largest and most typic in the whole state of Florida, for in it we find many rare and interesting tropic trees. It is about 3.2 kilometers (two miles) long and 1.6 kilometers (a mile) wide, extending down to the shores of Bay Biscayne. Through the center of it runs in a north-south direction the carriage road from Miami to Cocoanut Grove, 8 kilometers (five miles)

distant. The section which the road makes through the hammock affords unusual advantages to the botanist to study the layers of the forest, the heights of the trees, and their distribution as to light relationship. It also enables one to get vistas of the vegetation and good photographs of individual trees, or associations (Plate V, Fig. 2). The hammock vegetation belongs to the subtropic rain forest formation of Schimper.* Everything is new and bewildering to the northern botanist who visits a hammock of this kind for the first time. Two familiar trees, however, form important elements of the dominant growth, where the crown of the trees help to form the canopy above. They are the palmetto, Sabal palmetto (Walt.) R. & S., with tall and columnar stem, their bases covered with a gray moss, Octoblepharum albidum Hedw., and the live-oak, Quercus virginiana L. The palmetto tree was found in young growth in the forest and its leaves contribute materially to the forest litter. Occasionally among its leaf stalks grows a fern, Phlebodium aureum (L.) R. Br. The live-oak is a tree which forms a conspicuous part of the hammock vegetation. It branches freely and its large limbs bend into positions favorable for the most advantageous light exposure of the foliage (Plate V, Fig. 2). Its trunk and branches are loaded with epiphytes, which include the Florida-moss, Tillandsia usneoides (L.) Raf., that grows in festoons, two bird's nest bromeliads, Tillandsia valenzuelana A. Rich, Tillandsia utriculata L. and two orchids, Beadlea cranichoides (Griseb.) Small, and Epidendrum (Encyclia) tampense (Lindl.) Small. The live-oaks are frequently left when the other trees are cleared away, and in a number of places in the original hammock area near Miami, their form and load of epiphytes may be studied to advantage. The red-mulberry, Morus rubra L., above 20 meters tall, is among the larger trees of this forest, as are also the strangling-fig, Ficus aurea Nutt., F. brevifolia Nutt., and Coccolobis laurifolia Jacq. The strangling-fig, Ficus aurea Nutt., often begins its growth as an epiphyte by fruits carried by birds to the limb of some other forest tree. It sends down aërial roots, which grow about the trunk of the supporting tree, as they grow toward the soil beneath. These roots increase in number until the trunk of the host is surrounded and ultimately strangled. The Scotchman, as it is called locally, then entirely suppresses the other tree, which decays away within the encircling mass of roots, and the fig is left undisputed possessor of the ground and light position. Excellent representations of the Florida strangling-fig made from

* *Schimper, A. F. W.:* Pflanzengeographie auf physiologischer Grundlage, 500–505.

photographs taken near Miami are given in a paper by Ernst A. Bessey published in the 19th Annual Report of the Missouri Botanical Garden (pages 25–33, plates 1–9), and of a similar Mexican species by Trelease in the 16th Annual Report (pages 161–165, plates 39–45). The pond-apple, Annona glabra L., which becomes 14 meters tall, is present in Brickell Hammock. It plays a relatively unimportant rôle, but is associated with the Jamaica-dogwood, Icthyomethia piscipula (L.) A. Hitchc., bitterwood, Simarouba glauca DC., and crabwood, Gymnanthes lucida Sw. The gumbo-limbo, Bursera simaruba (L.) Rose, is a striking tree of the forest attaining a height of 20 meters and with a red-brown, smooth and shining bark, which peels off freely in papery layers like those of the yellow birch, hence another name for the tree, West Indian birch. The mahogany, Swietenia mahagoni Jacq., grows to be 25 meters tall in South Florida. The doctor gum, Metopium toxiferum (L.) Krug & Urb., is an element of the hammock formation. The bark is thin, splitting when old into large scales, red-brown outside and orange within. Its sap is poisonous to the skin. The introduced soapberry, Sapindus saponaria L., grows to be a tree 10 meters tall. The black-ironwood, Krugiodendron ferreum (Vahl) Urb., is an evergreen tree which sometimes grows to a height of 10 meters with a gray-ridged bark and green, velvety twigs. The mastic, Sideroxylon fœtidissimum Jacq., is an evergreen tree that becomes 25 meters tall. Finally, the list of dominant trees, as far as the material studied will allow, includes the ironwood, Eugenia confusa DC. (= E. Garberi Sarg.), the guava, Psidium guajava Raddi, satinleaf, Chrysophyllum olivaeforme L., bustic Dipholis salicifolia (L.) A. DC., and black calabash, Enallagma (Crescentia) latifolia (Mill.) Small.

The vines, or lianes, of the hammock formation include Smilax Beyrichii Kunth, wild vanilla, Vanilla Eggersii Rolfe, Gouania lupuloides (L.) Urb. (=G. domingensis L.), the bullace-grape, Muscadinia (Vitis) Munsoniana (Simps.) Small, with juicy, edible berries, the Virginia-creeper, Ampelopsis quinquefolia (L.) Planch., and Morinda roioc L. A reclining cactus, Acanthocereus pentagonus (L.) Britt. & Rose, occurs along the bluff facing Bay Biscayne and perhaps should be included among the vines. A diffusely branching vine of a dark-green color with narrow leaf blades and greenish flowers is Amphistelma scoparia (Nutt.) Small (=Metastelma scoparium (Nutt.) Vail). As a member of the family Asclepiadaceae, it has a copious, milky juice, and the writer suggests that on account of its rapid growth

and abundance in the forest, where it hangs down in dense, dark-green masses from the branches of the trees above, that it promises to be an important rubber-yielding species. In one place, where the railroad passes through the forest, Amphistelma is so abundant as to bear down, or choke, the trees on which it grows as a slender vine.

The secondary growth of small trees and shrubs fills up the light space and intervals beneath the dense canopy of lianes and branching trees of the upper story. An oak, Quercus myrtifolia Willd., grows to be 6 meters tall and is a constituent of the undergrowth. It is associated with another small tree of the same height, Trema floridana Britt., with yellow or orange drupes. A small tree of northern South America, Talisia pedicellaris Radlk., was discovered by the writer in Brickell Hammock, as new to Florida. It is included in Small's Miami Flora (p. 115) as a member of the family Sapindaceae. The coral-bean, Erythrina arborea (Chapm.) Small, with pods containing scarlet seeds, is a shrub 3–8 meters tall and has deltoid to hastate leaflets and few-flowered racemes. The writer was especially struck with this shrub as an important element of the forest. A euphorbiaceous shrub, found also in the Florida keys, the Bahamas and Cuba, grows in Brickell Hammock. It is Drypetes lateriflora (Sw.) Krug & Urb. The dahoon, or yaupon, Ilex cassine L., with red drupes, is a shrub, or small tree, with pubescent twigs. A number of other shrubs, or small trees, are present in this forest, such as: lancewood, Ocotea Catesbyana (Michx.) Sarg., Geiger-tree, Sebesten (Cordia) sebestena (L.) Britton, fiddlewood, Citharexylum fruticosum L., and princewood, Exostema caribæum (Jacq.) R. & S. Two shrubs, or small trees, considered out of their systematic sequence, are common and showy plants of the high hammock, viz., white-stopper, Eugenia axillaris (Sw.) Willd., with elliptic leaves and black, spheroidal fruits and French-mulberry, Callicarpa americana L. with serrate, rough leaves and clustered fruits which are violet to magenta in color. Its common occurrence in the south in rich woods is perhaps due to birds. The remaining shrubs collected by me in Brickell Hammock belong to the family Rubiaceæ. They are Hamelia erecta Jacq., rough velvet-seed, Guettarda scabra Vent., snowberry, Chiococca and two species of wild coffee, Psychotria undata Jacq. and P. Sulzneri Small. If we consider Morinda roioc L. to be a shrub and not a vine, it should be included as one of the rubiaceous shrubby constituents of the forest (Plate V, Fig. 2).

The herbaceous layer of the hammocks consists of such plants as a fern, Asplenium biscayanum (D. C. Eaton) A. A. Eaton, which grows on rocks about the margins of sink holes. The small cane, Panicum latifolium L., is common in Brickell Hammock, and two other grasses are conspicuous, viz., Andropogon tenuispatheus Nash (5–15 dm. tall) and Paspalum ciliatifolium Michx. Three sedges have been collected as part of the undergrowth, such as an acaulescent one, Abilgaardia monostachya (L.) Vahl, Cyperus brunneus Sw. and Scleria lithosperma (L.) Sw. Three euphorbiaceous plants are found in Brickell Hammock, as far as the collections of the writer go: Chamaesyce conferta Small, C. gemella (Lag.) Small and C. hirta (L.) Millsp., together with Rivina humilis L., 3–7 dm. tall, and Piriqueta tomentosa H. B. K. Finally, Afzelia pectinata (Pursh.) Kuntze (2–5 dm. tall), Wedelia trilobata (L.) A. Hitchc. with creeping stems and branches and Bidens leucantha (L.) Willd. naturalized from tropic America are elements of the third, or herbaceous, layer of the forest. The herbaceous vegetation cuts no important figure in Brickell Hammock. The plants that the writer collected there are enumerated above. They do not form pure associations, but are scattered beneath the shrubs and trees, here a species, and there a species, so that with other peculiarities the broad-leaved forests, or hammock vegetation, cannot be compared with the forests of temperate regions. The subsidiary species are perched, as epiphytes, suspended in air on the taller evergreen forest trees, while in temperate regions with periodic leaf-fall, the herbs are on the ground and flower usually before the leaves have developed fully. Two lianes are present in the sub-tropic forest which are found also in the forests of broad-leaved trees in Pennsylvania, and elsewhere, viz., the Virginia-creeper, Ampelopsis (Parthenocissus) quinquefolia (L.) Planch, which extends to the Florida keys, Bermuda, Bahamas and Cuba, and the poison-ivy, Rhus (Toxicodendron) radicans (L.) Kuntze, which extends likewise to the Florida keys, Bermuda and Bahamas, but apparently is absent in Cuba. With these few exceptions, the species are entirely different in the two forest regions.

At Immokalee, southwest of the Everglades, is a hammock covered with hardwood trees, the surface of which is 11.5 meters (38 feet) above sea level and the highest point between Ft. Myers and Brown's Store. Several other hammocks in the Big Cypress wilderness have received local notice. One of them is Deep Lake Hammock, reached by a trail running due south from

Immokalee and nearby are several wild orange groves, which presumably occupy high hammock land.

Long Key is a continuation of the oölitic limestone in a westward direction from the rock outcrops along the east coast, extending some kilometers south of Detroit. It touches the Everglades, and hence it is referred to as Long Key, Everglades. Besides the pineland, which we have described previously, hammock-land is found surrounding the eastern end of this key, so dense as to be penetrated only by the aid of an ax. It extends for a considerable distance, according to Small,* from the margin of the key, and instead of ending abruptly on a line where the growth of the pine trees begins, the hardwood trees of the hammock intermingle with the pines until the pines finally predominate. The trees of the hammock are draped with Spanish-moss and bear interesting ferns, orchids, and bromeliads. An enumeration of some of the plants noted in the Herbarium of the New York Botanical Garden will give some idea of the hammock flora on Long Key, Everglades.

Serenoa serrulata (Michx.) Hook, in flower May 6–7, 1904.
Tillandsia tenuifolia L., in fruit January 18–26, 1909.
Tillandsia valenzuelana A. Rich., in fruit January 18–26, 1909.
Epidendrum cochleatum L., in fruit May 6–7, 1904.
Epidendrum rigidum Jacq.
Trema floridana Britton.
Lysiloma bahamensis Benth., in fruit May 6–7, 1904.
Alvaradoa amorphioides Liebm., in fruit May 6–7, 1904.
Ilex cassine L., in fruit January 18–26, 1909.
Exothea paniculata (Juss.) Radlk., January 18–20, 1909.
Eugenia axillaris (Sw.) Willd., in fruit January 18–20, 1909.
Rapanea guyanensis Aubl., in fruit January 18–20, 1909.
Dipholis salicifolia (L.) A. DC., in flower May 6–7, 1904.
Bumelia microcarpa Small, in flower May 6–7, 1904.
Schoepfia chrysophylloides (A. Rich.) Planch.
Psychotria undata Jacq.

The hammock of Big Pine Key, to which reference has been made in the consideration of the pineland, is noteworthy for the presence of the following species in flower (+), fruit (—) and leaf (o) on February 27, 1911.

* *Small, J. K.:* Journal New York Botanical Garden, V: 159.

— Cenchrus carolinianus L.
o Galactia spiciformis T. & G.
± Chamaesyce Blodgetii (Engelm.) Small.
o Mimusops Sieberi A. DC.
± Solanum Blodgetii Chapm.
Ximenia americana L.
+ Ageratum littorale A. Gray.

LOW HAMMOCK FORMATIONS

The low hammocks are characterized by a wetter soil than the high hammocks and are found along streams, lakes, in the Everglades, along wet prairies, cypress swamps, tree and bush swamps and marshes. Three main kinds were studied by the writer, namely, river hammocks, pond hammocks and Everglade hammocks.

River Hammock Formation.—Although this formation is considered in the collective sense as including all hammock vegetation along river or stream banks, yet, strictly speaking, we can distinguish several kinds of river hammocks, such as live-oak hammocks, palmetto hammocks, or mixed tree hammocks. In South Florida, its river hammocks form an important part of the vegetation. They exist either as narrow strips paralleling the banks of the rivers, or they occupy ox-bow-like bends of the river bank, or form large areas many acres in extent. They were seen and in some places studied along the Miami, Little, New, and Caloosahatchee rivers (Plate VI, Figs. 1 and 2).

Along the Miami River, true hammock vegetation appears above the fork of the stream, especially in undisturbed condition on the South Fork. Here one notes as the constituent trees and shrubs, Chrysobalanus pellocarpus G. F. W. Mey., Erythrina arborea (Chapm.) Small, Citrus limetta Risso, gumbo-limbo, Elaphrium simaruba (L.) Rose, Ilex cassine L., Persea (Tamala) pubescens (Pursh) Sarg., Icacorea paniculata (Nutt.) Sudw., Psychotria undata Jacq. In one place at a bend of the stream, a hammock grove of live-oak trees was noted. These oaks were 15 meters (50 feet) tall with numerous twisted branches and gray bark. The branches were loaded with epiphytes. One species of Tillandsia, probably T. utriculata L., was a huge plant with its flat, dilated leaf bases overlapping to form a deep, basin-like hollow filled with water out of which the branched inflorescence arose. The Florida-moss, Tillandsia (Dendropogon) usneoides (L.) Raf., festooned the oak trees with long,

gray tresses. One of the most abundant low trees of the Miami river banks is the cocoa-plum, Chrysobalanus pellocarpus G. F. W. Mey., with purple fruits and orbicular, leathery leaves. The waxberry, Myrica (Cerothamnus) ceriferus (L.) Small, is also common, while the lianes are Smilax laurifolia L., poison-ivy, Toxicodendron (Rhus) radicans (L.) Kuntze, and bullace-grape, Muscadinia (Vitis) Munsoniana (Simps.) Small. If the plants at the water's edge of the hammock are included, then the most conspicuous of these plants are the tall tropic fern, Acrostichum aureum L., the spider lily, Crinum americanum L., and the shrub, Cephalanthus occidentalis L. The river plants proper will be considered later (Plate VI, Fig. 1).

Somewhat similar hammocks were noted on crossing Little River, where the live-oak trees of the forest were loaded with epiphytes, and on both sides of Arch Creek. Between Ft. Myers and the mouth of the Caloosahatchee River at Punta Rassa, my field notes indicate several noteworthy hammocks, usually on the land projecting into the river, as the stream makes its curves and rather open bends. Here the usual palmettos and live-oak trees loaded with epiphytes were noted from the steamer. Such hammocks come down to the river edge in some places, and in other places recede from the bank, which is lined with marshes and mangrove swamps. Back of the river the hammock vegetation blends in some places with the pine forest, in other places with marsh land. The height of the land above the river level determines the location of the several river-bank plant formations, whose location is determined almost entirely by amount of soil water and other edaphic conditions. Pure palmetto hammocks were noted, and in one place such a palmetto association broke through the mangrove fringe until the roots of the palmettos exposed by the washing away of the river bank were lapped by the water of the stream (Plate II, Fig. 4). Such hammock land was noted on the north and south banks of the Caloosahatchee River.

Opposite Ft. Myers, on the north bank of the river, Hancock Creek enters. This creek was followed for some distance inland by a motor boat. The mouth of the creek is characterized by a small hammock situated on the sandy bank of the river, back of which was salt marsh. The plants noted in this small river hammock were Sabal palmetto (Walt.) R. & S., Spanish-bayonet, Yucca aloifolia L., young live-oak trees, Quercus virginiana Mill., draped with Florida-moss, golden-fig, Ficus aurea Nutt., sea-grape, Coccolobis uvifera (L.) Jacq., a large prickly-pear, Opuntia sp., French-mulberry, Callicarpa americana

PLATE VI

FIG. 1

River hammock fronted by tall fern, *Acrostichum aureum* L., and spatter-dock, *Nymphæa advena macrophylla* Small, Miller and Standley, August 12, 1911. Original.

FIG. 2.

Palmetto hammock on the left bank of the stream (ascending), pine forest of slash-pine on the right bank of the Caloosahatchee River. Photograph by Hunt.

L., and two species of groundsel, Baccharis angustifolia Michx. and B. glomeruliflora Pers. The tall fern, Acrostichum aureum L., fronted this hammock on the water side. A single vine, Ampelopsis (Parthenocissus) quinquefolia (L.) Planch, was in evidence.

Still smaller stream hammocks consist of small groves of trees, such as: custard-apple, Annona glabra L., draped with pepper-vine, Ampelopsis arborea (L.) Rusby (=Cissus bipinnata (Michx.) Nutt.), Quercus virginiana Mill., and pop-ash, Fraxinus caroliniana Mill. At other turns, the elder, Sambucus canadensis L., forms rounded clumps, as does the waxberry, Cerothamnus (Myrica) ceriferus (L.) Small. At the head of navigation for small boats the hammock vegetation closes down on the river, so that the branches of the trees form an arch over the swiftly flowing water. The trees form such a close growth that it is impossible for a motor boat to ascend the creek at this point. Here the important trees are laurel-oak, Quercus laurifolia Michx., swamp-bay, Tamala (Persea) pubescens (Pursh.) Small, Spanish-stopper, Eugenia buxifolia (Sw.) Willd. and pop-ash, Fraxinus caroliniana Mill., associated with which were small trees and shrubs, such as: Cornus (Svida) stricta Lam., Rapanea guyanensis Aubl. The mistletoe, Phoradendron flavescens (Pursh.) Nutt., occurs as a parasite on the upper limbs of the pop-ash trees, while as epiphytes were gathered Tillandsia tenuifolia L. with narrow wiry leaves in such abundance as to be a character plant together with the large and conspicuous bird's-nest-like bromeliad, Tillandsia utriculata L., and the orchid, Epidendrum tampense Lindl. (=Encyclia tampense (Lindl.) Small. Here and there, Sabal palmetto (Walt.) R. & S. occurred with a large tropic fern, Phlebodium (Polypodium) aureum (L.) R. Br., perched in the axils of its lower leaves. Several lianes add to the inextricable confusion of the growth. They are Smilax sp., the poison-ivy, Toxicodendron (Rhus) radicans (L.) Kuntze, pepper-vine, Ampelopsis arborea (L.) Rusby, and an asclepiadaceous vine, Philibertella clausa (Jacq.) Vail.

Occurrence of Hammocks and Other Vegetation along Caloosahatchee River.— About 9.6 kilometers (6 miles) above Ft. Myers, the river changes abruptly. The banks are steep and the stream narrows to a width of about 54.7 meters (60 yards) with a deep strong current. Upcohall is a river landing, or backwoods settlement, beyond which the hammocks that line the river begin to form a conspicuous part of the river vegetation. The complexity of the hammock vegetation can be appreciated only by describing a cross-section of the

country between Upcohall and the Everglades. Although several different kinds of hammock land may be distinguished, yet the constituent species that are associated in these hammocks vary strikingly from place to place along the river banks. Although we have limited the number of different formations in the discussion which follows to a few selected, or generalized types, yet it must be clearly understood that the ecologic composition of these different formations is not as simple as the selected generalized name would suggest. The transition from one type of formation to an adjoining formation, as one ascends the river, is, as the following enumeration shows, almost kaleidoscopic, which suggests the applicability of Jaccard's law on the distribution of species in alpine meadows and pastures* to the hammock vegetation one meets in ascending the Caloosahatchee River. Palm-tree vistas that reach into the interior of the forest are broken by the palmetto hammocks, alternating with open prairies, with pineland or oak-saw-palmetto sclerophyllous scrub. A sudden bend of the stream will reveal one type of vegetation on the left bank and an entirely different association on the right. Since the settlement of the country much of the best river-bottom land has been cleared and planted to orange trees which in some large plantations were almost entirely submerged on June 20, 1912. The succession of hammocks and other formations noted on ascending the river from Ft. Myers to Lake Hicpochee is tabulated below. The formations on the right bank of the stream are placed in the right hand column, those on the left bank on the left hand side of the page. Beginning where the river narrows at Upcohall, the formations noted by me are as follows:

UPCOHALL

Pineland with scattered palmettos.	Hammock.
	Prairie with pine groves and palmetto strips.

RIVER VIEW

Hammock facing prairie.	Pineland.
Pineland fronted with thicket.	Hammock.
Saw-Palmetto Scrub.	Pine Savanna.
	Hammock.

* *Jaccard, Paul:* Distribution de la flore alpine dans le bassin des Dranses. Bull. Soc. Vaud des Sc. Nat. XXXVI:—, 1901; Étude comparative de la Distribution florale dans une portion des Alpes st du Jura. Bull. Soc. Vaud des Sc. Nat. XXXVII: 547–579. Lois de distribution florale dans la zone alpine. *Ibid.*, XXXVII, 1902; Gesetz der Pflanzenverteilung in der alpinen Region. Flora 90: 349–377, 1902; Nouvelle recherches sur la distribution florale. Bull. Soc. Vaud des Sc. Nat. XLIV: 223–270, 1908; The Distribution of the Flora in the Alpine Zone, New Phytologist, XI: 37–50, 1912. Jaccard states: "Nous en pouvons conclure *que le degré de fréquence d'une espèce dans une prairie donnée est essentiellement variable d'un point à un autre.*" From the studies presented in the papers above, we may conclude that the infinite diversity of the alpine flora, and of the associations which constitute it, is so great that probably no two square meters of vegetation in the whole chain of the Alps possess exactly the same floristic composition.

OLGA

Hammock.
Pineland with Saw-Palmetto.
Pineland.
Hammock.

Pineland.
Hammock.
Pineland.

IDALIA

Pineland.
Hammock.
Cypress Head.
Pineland fronted by river thicket.
Thicket.
Pineland.
Palmetto Hammock.

Pineland.
Hammock.
Palmetto Hammock.
Pineland with Saw-Palmetto.
Palmetto.
Palmetto Hammock.

OAK BLUFFS

Pineland.
Hammock.
Pineland.
Live-Oak-Palmetto Hammock.

Pineland.
Live-Oak Hammock.
Hammock.
Live-Oak-Palmetto Hammock.

RIALTO

Palmetto Hammock.
Pineland .4 kilometer (¼ mile) back.

Palmetto Hammock.
Pineland .4 kilometer (¼ mile) back.

NORMANDIE

Oak Hammock.

Dense Hammock .8 kilometer (½ mile) wide.

CALOOSA

Palmetto-Live-Oak Hammock.
Oak-Saw-Palmetto Sclerophyllous Forest.
Palmetto Hammock.

Palmetto-Live-Oak Hammock.
Pineland .4 kilometer (¼ mile) back.
Palmetto Hammock.

OWANITA

Oak-Saw-Palmetto Sclerophyllous Forest.
Pineland.
Oak-Saw-Palmetto Sclerophyllous Forest.

Hammock.
Pineland in rear of River Hammock.
Pineland.

ALVA

Pineland with Saw-Palmetto and low oaks.
Palmetto Hammock.
Tall Oak-Palmetto Sclerophyllous Forest with Pineland in the rear.
Low Oak-Saw-Palmetto Sclerophyllous Scrub.
Palmetto Hammock and large live oaks.

Pineland.
Oak-Saw-Palmetto Sclerophyllous Forest.
Palmetto Hammock with tall water hickory, Hicoria aquatica.
Tall Oak-Palmetto Sclerophyllous Forest.
Sclerophyllous Forest with Pineland in the rear
Palmetto Hammock.

FLOWEREE

Oak-Palmetto Sclerophyllous Hammock, with Pine Forest in the rear.
Pine Forest with Saw-Palmetto, oaks and palmetto.
Oak-Saw-Palmetto Scrub.
Pineland.
Tall Palmetto Hammock.
Sclerophyllous Hammock.
Pineland.

Palmetto Hammock with Pineland .8 kilometer (½ mile) from the river bank.
Pineland.
Oak-Saw-Palmetto Scrub.
Pineland.
Oak-Saw-Palmetto Scrub.
Pineland.
Oak-Saw-Palmetto Scrub with palmetto.
Pineland.

HANSFORD

Pineland.
Oak-Saw-Palmetto Sclerophyllous Forest.
Fine Hammock.
River Hammock.

Pineland.
Oak-Saw-Palmetto Sclerophyllous Forest.
Pineland.
River Hammock.

DENAUD

Oak-Saw-Palmetto Sclerophyllous Hammock.	Oak-Saw-Palmetto Sclerophyllous Hammock.
River Hammock backed by Pineland.	River Hammock backed by Pine Forest.

TURNERS

Oak-Palmetto Hammock backed with Pineland.	Oak-Palmetto Hammock backed with Pineland.
Palmetto Hammock .8 kilometer (½ mile) wide	Palmetto Hammock .8 kilometer (½ mile) wide.
	Pineland with Saw-Palmetto.

LABELLE

Oak-Palmetto Hammock with water hickory.	Oak-Palmetto Hammock with water hickory.
Prairie.	Prairie.

FT. THOMPSON

Live-Oak Hammock with scattered Palmettos.	Live-Oak Hammock with scattered Palmettos.
Live-Oak-Palmetto Hammock backed by Pine Forest.	Willow Thicket.
	Open Country backed by Live-Oak Hammock and tall Pine Forest.
	Palmetto Savanna.

LAKE FLIRT

(Bordered by a Willow Thicket)

Maiden-Cane Swamp and Willow Thicket.	Reed Swamp and Willow Thicket.
Hammock backed by Pine Forest.	

BONNET LAKE

Palmetto Hammock backed by Pine Forest.	Willow Thicket.
Small Palmetto Hammock of 21 Palmettos called Coffee Mill Hammock.	Prairie with Pine Forest along southern edge.
Prairie with Hammock and Pineland in the rear.	Prairie.
Prairie backed by Cypress Head.	Maiden-Cane Swamp with willows backed by Hammock.
Maiden-Cane Swamp and willow clumps with Hammock with Cypress and Palmetto in the rear.	

CITRUS CENTER

Prairie with scattered Palmetto Hammock.	Prairie.
Pine Forest runs out.	Everglades.

LAKE HICPOCHEE

Everglades.	Everglades.

Palmetto Hammock Formation (Plate VI, Fig. 2).—The typic river hammock formation of the Caloosahatchee River is one which consists almost entirely of pure growths of the palmetto, Sabal palmetto (Walt.) R. & S., with hardly any undergrowth, as the periodic inundations destroy the herbaceous growth and leave a slime that helps to produce the same effect (Plate VI, Fig. 2). The flood water too drives out the supply of oxygen in the soil upon which the health of the roots of the herbaceous plants depends, so that the plants succumb. Where the river banks have been washed away the large swollen bases of the palmetto trees with their short secondary roots on the rounded

balls, or stem bases, are exposed (Plate II, Fig. 4). Above the crown of broad, green leaves surmounts a cylindric stem 12–15 meters (40 to 50 feet) in height. Associated with the palmetto in some of the hammocks along the river, we find the pop-ash, Fraxinus caroliniana Mill, which reaches a height of 10 meters. The water hickory, Hicoria aquatica (Michx. f.) Britt., is a slender tree sometimes growing to be 30 meters tall and near the river's edge it mingles with the less tall palmetto. The palmetto in other hammocks is subordinated to the live-oak, Quercus virginiana Mill, forming what we will describe as the Live-Oak-Palmetto Hammock. Along the river, lianes are important elements of the palmetto hammock, the palm trees of which are draped with an almost crushing mass of vines, which include Vitis coriacea Shuttlew. with delicious berries, bullace-grape, Muscadinia (Vitis) Munsoniana (Simps.) Small, pepper-vine, Ampelopsis arborea (L.) Rusby (=Cissus bipinnata (Michx.) Nutt.), Virginia-creeper, Parthenocissus (Ampelopsis) quinquefolia (L.) Planch, and poison-ivy, Toxicodendron (Rhus) radicans (L.) Kuntze. To add to the density of growth, where every available light space seems to be filled with plants, the occasional live-oaks of this forest growth, as well as the palmettos, are festooned with the Florida-moss, Dendropogon (Tillandsia) usneoides (L.) Raf. Perched high on the palmetto tree and lodged beneath the crown of green leaves among the dead leaf-stalk stubs of the palm is the large epiphytic fern, Phlebodium (Polypodium) aureum (L.) R. Br., with its rhizomes covered with golden-brown hairs, or ramentæ, winding in and out among the palm leaf stubs. Attached to the palmetto below, this matted growth of the Phlebodium, the grass-fern, Vittaria lineata (L.) J. E. Smith, with its long, linear, pendent fronds, drapes the tree with its flowing tresses of green.

Beyond Labelle and near Citrus Center, the almost continuous river hammocks are found as detached islands surrounded by prairie vegetation (Plate VII, Fig. 1). Some of these hammocks are pure associations of palmetto trees. Coffee Mill Hammock, so called because a coffee mill was found in its midst, is such a hammock of 21 associated tall palmettos. It has become a conspicuous landmark to the river-men at the east end of Bonnet Lake before reaching the landing place on the canal at Citrus Center. Sugarberry Hammock at Citrus Center is another of these detached, or island, hammocks. A view from Citrus Center in a northwest direction shows the prairie assuming almost a savanna-like character by the presence of a number of these palmetto grooves (Plate VII, Fig. 1). Palmetto hammocks are found in the big coastal

prairie along the Florida East Coast Railroad south of Detroit in circular forms of large and small size surrounded with grass and sedge vegetation. In these hammocks the palmetto is conspicuous, as well as other sclerophyllous plants, such as Cerothamnus (Myrica) ceriferus (L.) Small. These hammocks become more common some distance southward, and there the prairie is dotted with them.

Live-Oak-Palmetto Hammock Formation.—The live-oak-palmetto hammock is a type of river hammock occurring in drier soil. The live-oaks, Quercus virginiana Mill, have spreading branches and form the dominant growth. Between these oaks and rising to an equal height the palmetto trees are scattered, or sprinkled through the hammock. Sometimes the palmetto trees are more abundant and the hammock approaches in ecologic character the type previously described. Where the palmetto trees are scanty the live-oak-palmetto hammock merges insensibly into one consisting of live-oaks. The branches of the live-oaks are loaded with epiphytes of various sorts, but one of the most conspicuous is the small green fern, Polypodium polypodioides (L.) A. S. Hitchc. (=P. incanum Sw.). Another common epiphyte is Tillandsia tenuifolia L., with wiry leaves of a reddish color, that grows in dense tufts on the limbs of the oak trees. The gray, flowing beards of the Florida moss, Dendropogon (Tillandsia) usneoides (L.) Raf., add to the gloom of such forests, which drip water in rainy weather. The prevailing gray color of the forest is heightened by the gray lichens that cover the bark of the large oak trees.

Live-Oak Hammock Formation.—This type of hammock is one of the series beginning with the palmetto river hammock. The series consist of palmetto hammock, live-oak-palmetto hammock, live-oak hammock. The live-oak hammock is comparatively open, as far as the undergrowth is concerned, but the abundance of epiphytes and the long festoons of the Spanish-moss fill up the available light space, so that the open, orchard-like character of the forest does not impress the observer. When this type of vegetation blends with certain elements of the pineland, we have another type of formation, which perhaps should be included with the dry hammock series, on the one hand, or with a modified type of pine forest on the other. Perhaps it should be considered distinct.

Oak-Saw-Palmetto Sclerophyllous Forest Formation.—Here the live-oak trees are of smaller size and more scattered, although the epiphytic growth on the oaks is as abundant as in the preceding type. This formation, however,

receives elements from the pine forest in the presence of low shrubby oaks and the saw-palmetto, Serenoa serrulata (Michx.) Hook., which is most common in the variety with glaucous leaves, giving heightened effect to the prevailing grayish-green color of the forest. Where the live-oak disappears, or reaches only the size of a tall shrub, we have a facies of this formation which may be termed the low oak-saw-palmetto sclerophyllous scrub. At a number of localities on the Caloosahatchee River, as enumerated above, this scrub, or chaparral, is seen, and perhaps in the denser types, it is similar to the maqui of the Mediterranean region. The oak-palmetto hammock is of general interest, because it is a type of forest known as sclerophyllous. The term sclerophyllous was first employed by Schimper for a xerophytic bushland, or bush forest, in subtropic regions,* such as South Florida, the Mediterranean countries, California, parts of Cape Colony and parts of West and South Australia. The trees have gnarled and twisted branches. They are evergreen and show various obvious features to meet the conditions which are not so severe as those of desert plants. None of the true tree species of the Caloosahatchee sclerophyllous forest become shrubs, because plentifully supplied with ground water, so that it resembles in physiognomy and ecologic constitution the Mediterranean oak forests rather than the Mediterranean garigues, or maquis. A low forest of evergreen oaks in Mediterranean countries grows on dry soil. As the orange, Citrus aurantium L., the carob, Ceratonia siliqua L., olive, Olea europaea L., are Mediterranean trees, the physiognomy and ecologic character of the Mediterranean forest suggest the advisability of planting the orange in situations where the vegetation, even if of entirely distinct species, yet shows similar peculiarities of sclerophylly. In matching vegetation and climates, we find such to be the character of the sclerophyllous forests between Caloosa and Denaud on the Caloosahatchee River, but the uncertain factor is the occasional inundation of the country during periods of excessive rain. With the control of the flood waters, this district, as far as the native vegetation serves as an index, ought to be one of the finest orange-growing regions in the world, for the whole aspect of the forest, with evergreen live-oaks draped with Florida-moss, with saw-palmettos, shrubby oaks and other xerophytic shrubs, suggests the Mediterranean sclerophyllous vegetation.

Where the saw-palmetto becomes the prevailing growth, this formation

* Typic sclerophyllous plants are found in regions with winter rains and dry summers; in contrast, Florida has wet summers and dry winters.

blends with the pine forest and is transitional to it, when the pines begin to be scattered amongst the shrubby oak trees. Hence the oak-saw-palmetto sclerophyllous formation stands intermediate between the live-oak hammock on the one hand and the pineland on the other. It is probably not a true river hammock, but should be included in the category of dry hammocks, but its geographic location and its transitional forms have led to its consideration at this place.

Pond Margin Hammock Formation.—Another kind of low hammock in South Florida is associated with the margins of the larger and the smaller lakes and ponds of the region, and the ecologic character of these different hammocks varies as much as the ponds around which they are found. One of the class may be taken as illustrative. Near Samville, a few miles north of the Caloosahatchee River, are a number of almost circular shallow ponds. One of these ponds was studied. The margin of the pond with the exception of a low, grassy area was fringed with a narrow hammock fronting the pineland on the side of the pond. The palmetto, Sabal palmetto (Walt.) R. & S., was the most important tree of the border strip. On the west side of the pond, the narrow hammock increased in breadth and here the palmetto was associated with live-oaks, Quercus virginiana Mill., persimmon, Diospyros virginiana L., and buttonbush, Cephalanthus occidentalis L., the trees were festooned with the Spanish-moss, Dendropogon (Tillandsia) usneoides (L.) Raf., and connected together by the Virginia-creeper, Parthenocissus (Ampelopsis) quinquefolia (L.) Planch. The branches of the oak trees supported dense masses of the epiphytic fern, Polypodium polypodioides (L.) A. S. Hitchc. (=P. incanum Sw.), while the bark of the branches was marked by the red blotches of a lichen, Chiodecton sanguineum (Sw.) Wain., mingling with the gray tones of another lichen, Parmelia laevigata (Sm.) Nyl. An epiphytic fern, Phlebodium aureum (L.) R. Br., previously described, sends its hairy rhizomes in and out of the petiole stubs of the palmettos, while the enlarged bases of these trees are characterized by three mosses: Bryum Sawyeri Rol., Plagiothecium (Isopterygium) micans (Sw.) Paris and Octoblepharum albidum Hedw.

Everglade Hammock Formation.—Finally among low hammocks must be included the hammocks that occur in the Everglades. As will be emphasized later, the hammocks increase in number in proceeding from Lake Okeechobee in a southwestern direction. The Everglades immediately south of the lake are practically without tree hammocks, but they increase as we proceed.

PLATE VII

FIG. 1.
Big prairie with two isolated palmetto hammocks near Citrus Center, Fla., June 21, 1912. Purchased.

FIG. 2.
Tall saw-grass of Everglades and everglade hammock at head of the Miami River, August 12, 1912. Original.

Along the North Canal, the first hammock was encountered 45 kilometers (28 miles) south of the lake. At 50 kilometers, a tree hammock was passed, while according to my notes the Everglades are dotted over with bushes 55 kilometers (32 to 34 miles) south of Lake Okeechobee. The canal makes a decided bend 55 kilometers (34 miles) south of the lake, and here a clump of willow trees and one of the buttonbush, Cephalanthus occidentalis L., were noted. From here to the outlet of the canal at the eastern edge of the Everglades, the small tree hammocks increase in number, until at 69 kilometers (43 miles), the skyline seems to be a continuous line of low trees through the union of the separate hammocks viewed from a distance across the vast saw-grass stretches. At a point 60 kms. south of the lake and 28 kilometers (17 miles) from Ft. Lauderdale, the first true everglade hammock was passed with a number of tall trees. These hammocks increase in number in an eastern direction. The distribution of these islands of tree vegetation in a sea of saw-grass suggests that the trees are gradually encroaching on the Everglades and in a westward direction.

One of the everglade hammocks (Plate VII, Fig. 2) a few kilometers west of the head of the Miami River may be taken as a type. Here I noted an association of such trees as: Ficus aurea Nutt., Annona glabra L., Magnolia virginiana L., Chrysobalanus pellocarpus Mey., Icacorea paniculata (Nutt.) Sudw., Rapanea guyanensis Aubl., with such shrubs as Salix longipes Anders, Myrica (Cerothamnus) ceriferus (L.) Small, Chrysobalanus icaco L., Tamala (Persea) pubescens (Pursh.) Small. Two lianes were collected in this hammock, viz., Smilax laurifolia L. and bullace-grape, Muscadinia (Vitis) Munsoniana (Simps.) Small, while on the ground the fern, Blechnum serrulatum L. C. Rich., was collected inside the hammock limits. The usual quota of epiphytes were present on the trees.

All through the country south of the Caloosahatchee River and west of the Everglades, comprising much of Monroe County, Florida, are found hammocks of greater or less size. At the southeastern corner of the Big Cypress is one sufficiently large to be marked on the map. Its general outline is U-shaped, or V-shaped, and the open area between the two arms is open glade. Several other large hammocks are found south of the wide glade which connects the Big Cypress Swamp with the saw-grass of the Everglades. Some of these hammocks are of the low variety, as they are associated with lakes, or ponds, of greater or less size. One of the hammocks in this part of Florida along the Chokoloskee River is characterized by the presence of a rare palm

of the Bahamas and Cuba, Paurotis Wrightii (Griseb. & Wendl.) Britton, which also grows in a swamp between Cape Sable and Madeira Hammock. Royal Palm Hammock, so called because of the presence of the royal-palm, Roystonea regia (H. B. K.) O. F. Cook, associated with saw-palmetto, Serenoa serrulata (Michx.) Hook., is an everglade hammock, and the vegetation of the hammock on Long Key (Everglades) adjoining the Royal Palm Hammock has been described in a previous section.

GENERAL LIST OF HAMMOCK PLANTS

The following list of hammock plants was compiled from the sheets preserved in the Herbarium of the New York Botanical Garden. The prefixed signs are: in flower (+); in fruit (—); in leaf (o).

— Andropogon tenuispatheus Nash. Miami, Oct. 28–Nov. 28, 1903.
+ Paspalum ciliatifolium Michx. Ft. Lauderdale, Nov. 19–25, 1903; Miami, Oct. 28–Nov. 28, 1903.
+ Oplismenus hirtellus (L.) R. & S. Miami, Oct. 28–Nov. 28, 1903.
+ Panicum agrostoides Muhl. Ft. Lauderdale, Nov. 19–25, 1903.
+ Panicum laxiflorum Lam. Near the Homestead Road, between Cutler and Longview Camp, Nov. 9–12, 1903.
— Panicum manatense Nash. Near the Homestead Trail and Camp Longview, May 13–16, 1904.
— Panicum Nashianum Scribn. Ft. Lauderdale, Nov. 19–25, 1903.
+ Cyperus ligularis L. Between Cocoanut Grove and Cutler, Oct. 31–Nov. 4, 1903.
— Abilgaardia monostachya (L.) Vahl. Brickell Hammock near Miami, Oct. 24–26, 1906.
+ Scleria Baldwinii Steud. var. costata Britt. Between Homestead and Camp Jackson, May 4–11, 1904.
— Scleria lithosperma (L.) Sw. Miami, Oct. 28–Nov. 28, 1903.
o Sabal palmetto (Walt.) R. & S. Near the beach, Palm Beach and elsewhere.
+ Xyris pallescens (C. Mohr) Small. Between Cocoanut Grove and Cutler, Oct. 31–Nov. 4, 1903.
+ Eriocaulon Ravenelii Chapm. Black Point, below Cutler, Nov. 13, 1903.
o Tillandsia utriculata L. Ft. Myers, Miami.
+ Habenaria repens Nutt. Hammock islands, between Homestead and Cross Key, Nov. 21–22, 1906.

± Habenella Garberi (Porter) Small. Brickell Hammock (on ground), Feb., 1911; Ft. Lauderdale to Miami, Feb., 1911; near Homestead Road, between Cutler and Longview Camp, Nov. 9–12, 1903.

— Polystachya minuta (Aubl.) Britton. Near the Homestead Road, between Cutler and Longview Camp, Nov. 9–12, 1903; between Cocoanut Grove and Cutler, Oct. 31–Nov. 4, 1903.

+ Epidendrum cochleatum L. (=Anacheilium cochleatum (L.) Hoffmg.). Near Homestead Road, between Cutler and Longview Camp, Nov. 9–12, 1903; Cauldwell Hammock, Dade Co., Mar. 26, 1904; —Long Key, May 6–7, 1904; Miami River, west of Miami, Nov. 1–9, 1901.

o Epidendrum rigidum Jacq. (=Spathiger rigidum (Jacq.) Small). Near the Homestead Road, between Cutler and Longview Camp, Nov. 9–12, 1904; near Long Prairie, Oct. 31, 1906; Cauldwell Hammock, Mar. 26, 1904; Long Key (Everglades), May 6–7, 1904.

— Epidendrum tampense Lindl. (=Encyclia tampense (Lindl.) Small). Ft. Lauderdale, Nov. 19–25, 1903; near unfinished railroad grade between Cocoanut Grove and Cutler, Oct. 31–Nov. 4, 1903; Miami, Oct. 28–Nov. 28, 1903.

— Cyrtopodium punctatum Lindl. Homestead Road, between Cutler and Longview Camp, Nov. 9–12, 1903; Miami, Oct. 27–Nov. 13, 1901.

+ Ficus aurea Nutt. South of Miami, Mar. 18, 1904.

— Ficus brevifolia Nutt. South of Miami, Mar. 21, 1904.

+ Morus rubra L. Key west of Royal Palm Hammock (Everglades), Jan. 26, 1909; Brickell Hammock, Feb. 13, 1907.

o Celtis mississippiensis Bosc. Unfinished railroad grade, between Cocoanut Grove and Cutler, Oct. 31–Nov. 4, 1903; between Perrine and Snapper Creek, Nov. 16, 1906.

+ Trema floridana Britt. Long Key (Everglades), May 6–7, 1904; Miami, May 7, 1904.

+ Magnolia virginiana L. Long Key (Everglades), Jan. 18–26, 1909.

+ Chrysobalanus icaco L. Miami, Oct. 28–Nov. 28, 1903.

+ Laurocerasus myrtifolia (L.) Britt. Near the Homestead Road, between Cutler and Longview Camp, Nov. 9–12, 1903; Cauldwell Hammock, Nov. 8, 1906.

o Lysiloma bahamensis Benth. Brickell Hammock, Oct. 24, 1906; —Long Key (Everglades), May 6–7, 1904; —near the Homestead Trail, Nov. 24, 1904; ±Cauldwell Hammock, Mar. 26, 1904.

+ Icthyomethia piscipula (L.) A. S. Hitchc. Miami, May 5–21, 1904; Brickell Hammock, Oct. 24–Nov. 26.

± Vicia acutifolia Ell. Ft. Lauderdale to Miami, Feb., 1911.

+ Xanthoxylum clava-herculis L. Ft. Lauderdale to Miami, Feb., 1911.

o Amyris elemifera L. Snapper Creek, south of Cocoanut Grove, Oct. 27–31, 1901.

± Alvaradoa amorphoides Liebm. +Cauldwell Hammock, Nov. 8, 1906; —Mch. 24, 1904; Homestead Trail, near Camp Longview, May 13–16, 1904.

— Bursera (Elaphrium) simaruba (L.) Rose. Miami, Oct. 28–Nov. 28, 1903; near Homestead Road, between Cutler and Longview Camp, Nov. 9–12, 1903.

— Picramnia pentandra Sw. Miami, Oct. 27–Nov. 13, 1901.

Simaruba glauca DC. Miami, Nov. 1–30, 1904.

o Swietenia mahagoni Jacq. Miami, Nov. 1–30, 1904.

o Gymnanthes lucida Sw. Brickell Hammock, Oct. 24–Nov. 26, 1904.

— Chamaesyce hypericifolia (L.) Small. Homestead to Big Hammock, Feb. 15–17, 1911.

o Mangifera indica L. Arch Creek, above Miami, Nov. 7, 1904; between Cocoanut Grove and Cutler, Nov. 13–23, 1903.

— Metopium toxiferum (L.) Krug and Urb. Long Key (Everglades), Mch. 6–7, 1904;—between Cocoanut Grove and Cutler, Nov. 13–23, 1903.

— Rhus leucantha Jacq. Between Homestead and Camp Jackson, May 4–11, 1904; —Nov. 9–12, 1903.

— Ilex cassine L. Long Key (Everglades), —Jan. 18–26, 1909; Ft. Lauderdale, Nov. 19–25, 1903; near the Homestead Trail and Camp Longview.

— Ilex Krugiana Loesener. Near the Homestead Trail, May 13–16, 1904.

o Sapindus saponaria L. Brickell Hammock, Feb., 1911.

+ Exothea paniculata (Juss.) Radlk. Long Key (Everglades), Jan. 18–26, 1909; Miami, May 5–21, 1904.

o Krugiodendron ferreum (Vahl.) Sarg. Brickell Hammock, Oct. 24–Nov. 26, 1906.

o Colubrina reclinata (L'Her.) Brongn. Near the Homestead Trail, about Silver Palm School, Nov. 24–27, 1904.

o Reynosia septentrionalis Urb. Miami, Mar. 19, 1909.

+ Passiflora suberosa L. Homestead to Big Hammock, Feb. 15–17, 1911.

± Ocotea Catesbyana (Michx.) Sarg. Brickell Hammock, Feb., 1911; Cauldwell Hammock, Mar. 26, 1904; —near Homestead Trail and Camp Longview, May 13, 1904.

+ Tamala borbonia (L.) Raf. (=Persea borbonia (L.) Spreng.). Miami, Mar. 18, 1904.

— Tamala pubescens (Pursh.) Small (=Persea pubescens (Pursh.) Small). Ft. Lauderdale, Nov. 14 and 25, 1903; Sink Hole in Pineland, near Long Prairie, Mar. 24, 1904.

o Eugenia buxifolia Willd. Near the beach, Palm Beach, Nov. 19, 1904; Miami, Oct. 28–Nov. 28, 1903.

– Eugenia axillaris (Sw.) Willd. Long Key (Everglades), Jan. 18–26, 1909; Miami, Mar. 19, 1904; –near Homestead Trail, about Silver Palm School, Nov. 24–27, 1904.

± Rapanea guyanensis Aubl. Long Key (Everglades), Jan. 18–26, 1909; + about New River Sound, below Ft. Lauderdale, Nov. 25, 1904; –south of Miami, Mar. 18, 1904.

+ Icacorea paniculata (Nutt.) Sudw. Near Homestead Road, between Cutler and Longview Camp, Nov. 9–12, 1903; ±Miami, Oct. 27–Nov. 13, 1901.

o Chrysophyllum olivaeforme L. Near Homestead Trail, about Silver Palm School, Nov. 24–27, 1904; –Snapper Creek, south of Cocoanut Grove, Oct. 27–31, 1901; –between Cocoanut Grove and Cutler, Nov. 13–23.

– Sapota achras Mill. Arch Creek, above Miami, Nov. 7, 1904; between Cocoanut Grove and Cutler, Nov. 13–23.

+ Bumelia microcarpa Small. Homestead to Big Hammock Prairie, Feb. 15–17, 1911; Long Key (Everglades), May 6–7, 1904.

+ Dipholis salicifolia (L.) A. DC. Miami, Apr. 10, 1904; Long Key (Everglades), May 6–7, 1904.

– Sideroxylon foetidissima Jacq. Ft. Myers, July and Aug., 1911; Snapper Creek, south of Cocoanut Grove, Oct. 27–31, 1901.

+ Solanum verbascifolium L. Near the Homestead Road, between Cutler and Longview Camp, Nov. 9–12, 1903; Miami, Oct. 28–Nov. 28, 1903.

– Crescentia latifolia Mill. Brickell Hammock, Feb., 1911; near Little River, Apr. 4, 1909.

– Guettarda scabra Vent. Ft. Lauderdale, Nov. 19–25, 1903.

± Psychotria undata Jacq. Long Key (Everglades), May 6–7, 1904;– Miami, Oct. 28–Nov. 24, 1903.

CYPRESS SWAMP FORMATIONS

One of the most conspicuous and characteristic plant formations of the southern states, as well as of Florida, is one in which the swamp-, bald-, or deciduous cypress, Taxodium distichum (L.) L. C. Rich., plays an important rôle. The cypress is nearly confined to the coastal plain from southern Delaware to southern Florida, westward near the Gulf of Mexico to Texas, and up the Mississippi Valley to Missouri and Indiana. Closely related to it is a species, Taxodium imbricarium (Nutt.) Harper (=ascendens Brongn.), which grows in

ponds away from the coast underlaid by the Columbia and Lafayette geologic formations from Dismal Swamp, Virginia, to Florida and Louisiana.* Taxodium distichum usually has an enlarged, conic, buttressed base with the longitudinal ridges usually flat, quite sharp and prominent. Its knees are large and pointed. In Taxodium imbricarium, the enlargement of the base is abrupt and conoidal and its ridges are rounded. The knees of this variety are rounded, or hemispheric, or may be entirely wanting. The leaves are closely appressed, while in T. distichum they are spreading and distichous. Small in his Miami Flora gives Taxodium distichum as the only species of the limestone region of Southeast Florida. As T. imbricarium is a calciphobe species, it is probably not represented, but in southwest Florida, about 9 kms. south of Ft. Myers in a cypress bay, or head (Plate IX, Fig. 1), nearly all of the trees had the enlargement characteristic of Taxodium imbricarium in a soil of sand with no evident limestone. Following Sargent, I have represented on my colored phytogeographic map of North America, the southern limit of Taxodium distichum as at Jupiter Inlet on the east coast of Florida, while in reality, according to later observations, it is found growing almost at the extreme southern end of the peninsula on both the east and the west coasts, as indicated on the accompanying map. The last outpost, according to the observations of the writer, is at the edge of a prairie 16 kilometers (10 miles) south of Miami, between Larkin and Kendell (see map), which is about 32 kilometers (20 miles) north of the extreme southern limit of the slash-pine, Pinus caribaea Morelet, on the mainland at Detroit. The writer was informed on good authority that the southwest limit of the cypress in Monroe County is fixed by the limits of the survey made by J. S. Frederick in 1902, for his survey ended at a point where it was impossible to penetrate the dense cypress swamps. On the large blue map of Dade and Lee, also parts of Monroe, De Soto, and Manatee counties, Florida, the end of that survey is marked R. 34 E. and T. P. 54 S. Dr. John K. Small has informed me that he has seen a few cypress trees in the neighborhood of Long Key (Everglades), and on the map just mentioned at the head of North and Roberts rivers, a wet prairie with small cypress is given, so that the cypress tree extends much farther south than Sargent believed; in fact, it extends to the southern end of the peninsula, but

* *Harper, Roland M.:* Taxodium distichum and related Species, with Notes on some geological Factors influencing their Distribution. Bull. Torr. Bot. Club., 29: 383–399: Further Observations on Taxodium. Bull. Torr. Bot. Club, 32–105–115.

PLATE VIII

Fig. 1.

Cypress swamp and marsh vegetation with open lagoons covered with water lilies, August 11, 1911, west of West Palm Beach. Original.

Fig. 2.

Cypress head near Six-mile Cypress, June 12, 1912. Right tree of group with epiphytic bromeliad, Tillandsia fasciculata Sw. Third tree (second from left) with epiphytic orchid, Epidendrum tampense Lindl. (= Encyclia tampense (Lindl.) Small.) Original.

is not found on the Florida keys (see map). The geographic distribution of the cypress in South Florida is of unusual interest, as it throws considerable light upon the succession of vegetation in the southern part of the peninsula. The cypress, as far as the observations of the writer are concerned, exists in areas of greater or less size, which may be differentiated by the following descriptive terms: Cypress Swamp, Branch Cypress Swamp, Cypress Pond, Cypress Bay, Cypress Head, Cypress scattered along river banks and ponds, Cypress Scrub.

Cypress Swamps.—The areas denominated cypress swamps are true swamps and covered with water the greater part of the time. The soil is largely muck, but outcroppings of sand and rock occur. The trees are usually large with conic, buttressed bases (Plate IX, Fig. 1), and the knees are pointed at the extremity. The influence of age is to cause the summit of the trees to become flat-topped, and this flattening of the crown is in direct contrast to the spire-shaped form, as first emphasized by William P. Wilson* in his study of this species in Florida. Taxodium distichum (L.) L. C. Rich. is the dominant tree, and associated with it are other trees, shrubs, lianes and ferns. The trees are usually draped with Florida-moss. Other epiphytic orchids and bromeliads grow upon the trunk and branches of the cypress trees. Ecologically, a cypress swamp resembles one of broad-leaf deciduous trees in the fact that the leaves of the cypress are deciduous and the swamp has a more open sunlit character in the winter, when the cypress trees are leafless, than in the summer, when the light-green foliage shades the subordinate vegetation beneath the dominant cypress trees. If one approaches a cypress swamp through a pine forest in summer, the light greens of the cypress foliage and the close set growth of the trees give an impression of gloom, but in winter the swamp is more open and sunlit than the pine forest and the light-green color of the mass of cypresses is changed to a grayish tone.

Large cypress groves are located along the north, northeast and east shores of Lake Okeechobee, where above Pelican Bay a ridge of fine silicious sand runs along the shore of the lake. This ridge is several feet high and varies from about 8 to 60 meters in width. Behind this ridge lies a dense cypress swamp with majestic cypresses draped from top to bottom with festoons of Spanish-moss, exhibiting the sylvan wonders of this primeval solitude.

* *Wilson, W. P.:* The Production of Aërating Organs on the Roots of Swamp and other Plants, Proc. Acad. Nat. Sci. of Phila., 1889: 67; The Bald Cypress. Forest Leaves II: 110 (1889).

Along the shore here is open and clean sand. The ridge of sand, or ancient dunes, is clothed with bald-cypress and palmetto and the growth is almost impenetrable in many places. According to Small,* we find the maple, Acer carolinianum Walt., holly, Ilex cassine L., pop-ash, Fraxinus caroliniana Mill., many shrubs and herbs associated with the cypress trees. The cypress swamp along the north and northeast shore of Lake Okeechobee ascends Taylor Creek and stretches along the eastern shore of the lake to T. P. 41 S., which is one section north of Pelican Bay and the outlet of the projected West Palm Beach Canal. Cypress swamps (see map) are found along the eastern border of the Everglades and the headwaters of the larger streams that flow eastward into the Atlantic. The largest cypress swamp in South Florida is known as the Big Cypress. It is west of the Everglades in the southwestern part of the peninsula. As the Everglades occupy part of the lake basin of an ancient Lake Okeechobee, the cypress, which is found on the shores of the present lake, is continued southward along the edge of the ancient lake, now the eastern and western borders of the Everglades. A large body of bald-cypress is found along the border of the Everglades, where the Loxahatchee Marsh meets the 'Glades. It continues some distance on both sides of the Loxahatchee Marsh, as it extends north to drain north into Jupiter River. From the Loxahatchee Marsh (see map), the cypress continues in bodies of greater or less size, often interrupted in their continuity, as far south as Cypress Creek. There the almost continuous cypress border is broken and the cypress groves are only found about the headwaters of such rivers as the New and the Miami.

The exact size of the Big Cypress Swamp (Indian name, Atseenahoofa) is not known with any exactitude. Sargent in his Tenth Census Report on the Forests of the United States (page 52) says that it is about 236 kilometers (85 miles) long and 32 kilometers (20 miles) wide, and covers about 259,000 hectares (1000 square miles). These figures are probably too great, as the country which was formerly included in the Big Cypress has been proved by several surveys to be of a diversified character. The cypress swamps alternate with hammocks, prairies, swamp-land and pineland, so that there are not continuous bodies of cypress. However that may be, the Big Cypress represents the largest undisturbed cypress forest in the world.

Branch Cypress Swamps.—These are cypress swamps that are found in

* *Small, John K.:* Exploration in the Everglades and on the Florida Keys. Journ. N. Y. Bot. Gard., 15: 69–79, Apr., 1914.

dense stand along the banks of some river, creek, or rivulet, the water level in the swamp being conditioned by the height of the stream. If the stream is a small one, it may run dry in the dry season. The outline of such swamps varies with the stream bank on which they are found. If the ground is flat and flooded by the stream, the cypress swamp may cover considerable areas in length and breadth. If the banks are steep, the cypress may grow in a narrow strip of trees on both sides of the stream. Where such grow along a meandering stream, the snake-like, or sinuous course of the branch swamp may be traced by its light green color in summer, or by its open gray tones in winter, as contrasted with the dark green of the pine forest about it. Two branch cypress swamps of this character were investigated near Samville, a small town north of the Caloosahatchee River and at Six-Mile Cypress, 12.8 kilometers (8 miles) south of Ft. Myers.

The stream at Samville was almost a meter wide. In sandy soil on both sides of it and covering an area of about 1 hectare was a cypress swamp where Taxodium distichum (L.) L. C. Rich. was the dominant tree. Associated with the cypress was the pop-ash, Fraxinus caroliniana Mill., and the herbaceous undergrowth, as collected by me, consisted of the grass, Syntherisma serotinum Walt., the sedges, Cyperus echinatus (Ell.) Wood, C. paniculatus Rottb., Rhynchospora perplexa Britt., and the plants, Ascyrum hypericoides L., Sabbatia campanulata (L.) Torr., Gratiola ramosa Walt., Dianthera crassifolia Chapm., Conoclinum dichotomum Chapm., Pluchea foetida (L.) B. S. P., and Coreopsis Leavenworthii T. & G.

Six-Mile Cypress is at the northern edge of the Big Cypress region and its flora is probably somewhat similar to that found in the Big Cypress proper. Six-Mile Cypress drains into Hendry Creek, which empties into Estero Bay on the Gulf of Mexico. In June, 1912, when Six Mile Cypress was visited, it was inundated with water and to study its vegetation the writer waded up to his waist in water. The swamp-cypress, Taxodium distichum, was the dominant tree, and its knees were plentifully distributed through the swamp. One knee was of a ∩-shaped, or yoke form, the curved upper part being covered with a gray lichen, Parmelia sp. Such a knee suggests those that are formed experimentally in sour-gum trees and in the roots of maize, when they are flooded with water. Associated with the cypress, draped with Spanish-moss, Dendropogon usneoides (L.) Raf., were the palmetto, Sabal palmetto (Walt.) R. & S., laurel-oak, Quercus laurifolia Michx., the red-maple, Acer rubrum L., the pop-ash, Fraxinus

caroliniana L., Rapanea guyanensis Aubl. The shrubs collected beneath the trees were the waxberry, Cerothamnus (Myrica) ceriferus (L.) Small, Ilex cassine L., and the buttonbush, Cephalanthus occidentalis L. Two ferns were gathered here, viz., the Virginian chain-fern, Anchistea virginica (L.) Presl. (=Woodwardia virginica (L.) Presl.), and Blechnum serrulatum L. C. Rich. The true aquatic plants are Sagittaria lancifolia L. and Pontederia cordata L. The true grasses and sedges are represented by Tripsacum dactyloides L., Coelorachis (Manisuris) rugosa (Nutt.) Nash and Rhynchospora corniculata (Lam.) A. Gray. The epiphytic plants of the Six-Mile Cypress are represented in my collection by Tillandsia fasciculata Sw., Epidendrum tampense Lindl. (=Encyclia tampense Lindl.) Small (Plate VIII, Fig. 2). The list of secondary herbaceous species is completed by Boehmeria cylindrica (L.) Willd., Lythrum lanceolatum Ell. and Teucrium Nashii Kearney.

Cypress Ponds.—These are very numerous in the South Florida flatwoods. They are of various sizes and shapes, but usually approximately circular, or elliptic, and from .4 to 40 hectares (one to a hundred acres) in extent. In wet weather the water in them may be as much as 6 dm. (2 feet) deep, while in the late spring they are usually dry, or nearly so.

Cypress Bays.—Cypress bays (Plate VIII, Fig. 1) are related to cypress ponds, but seem to differ chiefly, as far as environmental conditions are concerned, in being situated on deeper sand (cypress ponds generally have clay, sometimes rock under them within a few feet of the surface) and having less fluctuation of water level, and the water seems to be more acid than in cypress ponds. Roland M. Harper* gives the constituent plants of such bays in the northern part of Florida.

Cypress Heads.—Like pine islands, cypress also appears in isolated clumps, or groves called heads. These heads always indicate low wet ground, which is usually covered with water during the entire year. Such a head was investigated 9 kilometers (six miles) south of Ft. Myers in the middle of the pine forest. The dominant tree is Taxodium imbricarium (Plate IX, Fig. 1, for corroboration of this statement) with a base that is swollen into a bulb-like enlargement with a flat rim above on which a fern, Blechnum serrulatum L. C. Rich, was found on June 12, 1912 (Plate IX, Fig. 1). An epiphytic bromeliad, Tillandsia fasciculata Sw., was attached to the trunk above and an epiphytic orchid, Epiden-

* *Harper, Roland M.:* Preliminary Report on Peat. 3rd Annual Report Florida Geological Survey, 264.

PLATE IX

FIG. 1.

Cypress tree base in cypress head 9 kilometers south of Ft. Myers; the fern, Blechnum serrulatum L. C. Rich., is growing on the base of the cypress, June 12, 1912. Original.

FIG. 2.

Floating rafts of water-hyacinth, Piaropus crassipes (Mart.) Britton, mixed with arrow-leaf, Sagittaria lancifolia L., on Lake Flirt. Photograph by Hunt.

drum tampense Lindl. (=Encyclia tampense (Lindl.) Small) grew in similar positions in full flower (Plate VIII, Fig. 2). Beneath the trees grew Sabbatia dodecandra (L.) B. S. P. with large pink flowers about 5 centimeters (2 inches) in diameter on long flexuous stems. The cypress trees of this head were not festooned with Spanish-moss, but the waxberry, Myrica (Cerothamnus) ceriferus (L.) Small, was an abundant shrub beneath the cypress trees. About half a dozen of these heads were noted in the country between Ft. Myers and Six-Mile Cypress.

Scattered Cypress along Rivers and Ponds.—Along the Miami and New rivers large cypress trees are found growing as isolated specimens, or in small groves. The most southern group of cypress trees noted at a point between Larkin and Kendall comprised about 3 to 4 trees. All along the Caloosahatchee River, isolated cypress trees grow. The localities on this river where they were noted is as follows:

Atlantic Coast Line R. R. (drawbridge).
Cypress Head with trees draped with Spanish-moss.

Upcohall.
Occasional Cypress trees.

Idalia.
Cypress Head on left bank.

Oak Bluff.
Cypress occasional.

Rialto.
Cypress occasional.

Owanita.
Tall cypress at river edge.

Alva.
Cypress.

Floweree.
Cypress loaded with epiphytes.

Bonnet Lake.
Cypress mingles with the pine forest back of the hammock strip to the left ascending the river.

Coffee Mill Hammock.
Dense stand of cypress blending with frontal hammock and pine forest.

Lake Okeechobee.
Single cypress, as a landmark or range tree, situated at the opening of the canal into Lake Okeechobee. In the custard-apple forest, which characterizes the southwest and south shores of Lake Okeechobee, tall cypress trees grow above the general level of the dominant custard-apple trees, Annona glabra L.

Cypress Scrub.—The only information the writer has of this type of cypress growth, if it merits recognition as a distinct association of physiognomic difference, is in a letter from the post-mistress at Immokalee in reply to one directed to that place for information about the Okaloacoochee Slough. Southwest of Immokalee, the Everglades form a narrow embayment, which joins on to the

Big Cypress Swamp to the west. Where the two formations join, the saw-grass is still dominant, but there are clumps of low, spreading, or dwarf cypress trees, which in association form what is called cypress scrub. Probably the cypress scrub does not merit to stand as a distinct association, as it probably represents pioneer cypress trees that have invaded the outer edge of the arm of the Everglades.

It is interesting that so many of the terms which we have used in our description of South Florida vegetation from an ecologic standpoint and based on a careful analysis of the flora and the factors which control the distribution of the typic plants should have their counterpart in the everyday usage of the unscientific and often uneducated inhabitants of South Florida. Such terms as hammock, prairie, cypress pond, cypress swamp, cypress head, cypress bay, savanna are in current use and this unscientific usage shows that these formations are natural groups of the vegetation easily recognized as such by the South Florida habitant. Graebner, in his book, "Die Heide Norddeutschlands,"* remarks on this point, as follows: "Es ist merkwürdig, wie die Zusammengehörigkeit und wieder die Verschiedenheit aller dieser Vegetationsformationen und noch vieler anderer beim Volke, dem einfachen Landmann, der keinerlei höhere Schulbildung besitzt, viel mehr und besser bekannt und erkannt ist als vieler Gelehrten. In wenigen pflanzengeographischen Werken finden wir Andeutungen über eine Einteilung der Vegetationsformationen auf einer natürlichen Grundlage, ja in ganz bekannten Werken sind z. B. merkwürdige Verwechselungen von Grünland- oder Wiesenmoore mit Heidemooren zu lesen und Grundirrtümerpflanzen sich von Buch zu Buch fort. Dem Bauern dagegen is oft ganz genau bekannt, was sein Boden tragen kann und was nicht. Ich habe mehrfach Gelegenheit genommen Landleute zu fragen, welche Bäume und Sträucher der Gegend sie auf dieses oder jenes Gelände bringen würden, und war oft erstaunt über wohl instinctiv richtige Antwort."

POND AND LAKE VEGETATION

Numerous ponds and lakes are scattered through the southern part of the peninsula of Florida. A reference to the accompanying map will show the location of many of these smaller or larger bodies of fresh water. Ponds in

* Die Vegetation der Erde, V (1901): 14.

the sense of the natives of South Florida are depressions permanently filled with water, or containing water only during the rainy season (wet-weather ponds), and both kinds either with an open surface of water, or with a luxuriant growth of plants. They are designated by the plant which is most prominent (dominant in the ecologic sense).

Saw-grass ponds, where the saw-grass is found growing from 6 dm. to 3.6 meters (2 to 12 feet) high in either muck or marl.

Pop-ash ponds with the pop-ash, Fraxinus caroliniana, as a low scrubby tree, seldom growing higher than 8.6 meters (25 feet) in clumps of 12 or more stems arising from a single root.

Flag ponds filled with the "fireflag," an unidentifiable plant (perhaps Iris, or Orontium) from the description of a backwoodsman alone.

Maiden-cane ponds, distinguished by the maiden-cane, Panicum hemitomon Schult., which grows out of a bottom of white sand to a height of 6–12 decimeters.

Cypress ponds where the cypress is prominent. Good drinking water may be had in these ponds during the dry season at a depth of a meter or less.

In the limited time at the disposal of the writer, one of the larger flatwoods ponds about 40 ares in extent was visited near Samville. The water surface of the pond was broken by clumps of the switch-grass, Panicum virgatum L. The floating aquatic plants were represented by only one species, viz., Azolla caroliniana Willd., while the submerged aquatics comprised Naias flexilis (Willd.) Rost. & Sch. The wet muck soil of the pond margin was a sedgy strip, where various species of sedges and other herbaceous plants were found in association, as follows: Cyperus paniculatus Rottb., Fimbristylis autumnalis (L.) R. & S., Dichromena colorata (L.) A. S. Hitchc., Iris caroliniana S. Wats., Persicaria hydropiperoides (Michx.) Small (growing out in the shallow water), Hypericum mutilum L., Lythrum vulneraria Ait., Eryngium Baldwinii Spreng., Ptilimnium capillaceum (Michx.) Hollick, and Diodia virginiana L. The hammock vegetation surrounding this pond near Samville has been described under that head and need not be considered here. A comparative study of the pond vegetation of South Florida would yield a rich harvest of plants and would be a profitable study for some ecologically inclined botanist. Incidentally, while overhauling the South Florida plants in the Herbarium of the New York Botanical Garden, the following plants were listed:

ADDITIONAL POND PLANTS*

Erianthus saccharoides Michx.
Tripsacum dactyloides L.
Coelorachis (Manisuris) rugosa (Nutt.) Nash.
Panicum Baldwinii Nutt.
Panicum erectifolium Nash.
Panicum virgatum L.
Chaetochloa corrugata parviflora Poir.
Aristida patula Chapm.
Cyperus brunneus Sw.
Cyperus cylindricus Britton
Fimbristylis autumnalis R. & S.
Fimbristylis castanea (Michx.) Vahl.
Dichromena latifolia Baldw.
Dichromena leucocephala Michx.
Rhynchospora fascicularis Vahl.
Rhynchospora Hitchcockii Britton
Rhynchospora stipitata Chapm.
Rhynchospora Tracyi Britton
Scleria gracilis Ell.
Xyris ambigua Beyr.
Eriocaulon decangulare L.
Juncus scirpoides Lam.

Besides the ponds which in great numbers are scattered through South Florida, the section of the state south of latitude 27° 30′ North boasts a number of lakes of small and large size. Enumerated, the smaller lakes are Hares, Buck, Red, Beach, Josephine, Allie, Nellie, Clay, Stearns, Apthorpe, Childs, Annie in the Kissimmee drainage system, and Lake Flirt (Plate IX, Fig. 2), while in the extreme southern end, we have Deep Lake, south of the Big Cypress, Long Lake and Cuthbert Lake near Cape Sable. The larger lakes of the area are Trafford, Hicpochee, Istokpoga and Okeechobee. The vegetation of Lake Flirt, Lake Hicpochee and Lake Okeechobee will be considered as representative.

Lake Flirt (Plate IX, Fig. 2).—This lake belongs to the Caloosahatchee River and is merely a widening of the headwaters of that stream, and since the construction of the canal, Lake Hicpochee may also be considered as a part of the Caloosahatchee River system. The canal passes through Lake Flirt, which in times of dry weather is scarcely more than a marshy tract, largely overgrown with grasses, flags, and various water plants. When the writer passed across Lake Flirt on June 21, 1912, the country was inundated with water and the following description taken from the field note book will give a general idea of the vegetation of the lake. Before the lake is reached, the country opens out with scattered palmetto hammocks. Lake Flirt is bordered by an association of willows. The left bank is characterized by a growth of maiden-cane,

* Consult for others *Hitchcock, A. S.:* A list of Plants collected in Lee County, Fla. Proc. Ia. Acad. Sci. IX (1901): 189–225.

Panicum hemitomon Schult., a tall grass (6–12 dm. tall) from stout rootstocks. A vine, Ampelopsis arborea (L.) Rusby (= Cissus bipinnata (Michx.) Nutt.), climbs up the maiden-cane. Back on the right is a hammock with tall pine forest in the rear. The reed marsh at the east end of Lake Flirt is followed along the canal by willow thickets which fringe that evasive body of water called Bonnet Lake. The water-lettuce, Pistia stratiotes L., was floating on the surface of Lake Flirt, as also the water-hyacinth, Piaropus crassipes (Mart.) Britton, which in dense masses (Plate IX, Fig. 2) was anchored between the clumps of willows.

Lake Hicpochee is a large lake with a basin like a soup plate, surrounded by saw-grass marsh. Along the north border of the lake were associations of bonnets, Nymphaea (Nuphar) advena Soland, associated with the pondweed, Potamogeton sp. The border of the lake is flat with a green rim of low plants which along the east shore of the lake consisted of the tall fern, Acrostichum aureum L., saw-grass, Cladium effusum (Sw.) Torr. (= Mariscus jamaicense Crantz), Britt. Sagittaria lancifolia L., and the herbs Kosteletzkya altheæifolia (Chapm.) A. Gray in flower (June 21), Hibiscus grandiflorus Michx., and Pluchea purpurascens (Sw.) DC. Scattered along the shores of the lake were noted low custard-apple trees, Annona glabra L., willows, Salix sp., waxberry, Myrica (Cerothamnus) ceriferus (L.) Small, elder, Sambucus canadensis L. Over these shrubs climbed a vine, Ampelopsis arborea (L.) Rusby, and a moon-flower, Calonyction aculeatum (L.) House. The water-lettuce, Pistia stratiotes L., floated on the surface of the lake in extensive rafts.

Lake Okeechobee.—Lake Okeechobee is a beautiful body of clear water almost circular in shape and about 48 kilometers (30 miles) across, and is the largest freshwater lake wholly within the United States except Lake Michigan. At mean level it covers an area of 189,751 hectares (468,860 acres). At the high stage, its surface is about 6.8 meters (22.5 feet) above tide level and at low water, 5.7 meters (19 feet). The lake is quite shallow, the deepest places not exceeding 6 to 7 meters at low water and the average depth is 3.657 meters (12 feet). It shows several islands at the southern end, viz., Observation, Rita, Torry and Kreamer. Torry Island is covered with hammocks, acres in extent, surrounded by dense growths of custard-apple trees with curiously buttressed or branched trunks. Access to this island is made difficult by extensive liquid mud flats which surround it and in which grow the maiden-cane, Panicum hemitomon Schult., bulrush, Scirpus validus Vahl., water-hyacinth,

Piaropus crassipes (Mart.) Britton, water-lettuce, Pistia stratiotes L., and pennywort, Hydrocotyle umbellata L.

The shores of Lake Okeechobee are low and not well-defined. As the lake rises, its waters inundate the flat country and the shore line recedes several miles, so that the area of the lake is much larger at high than at low water. The bed of the lake, except in the southern part, is a fine hard sand and presents a comparatively smooth and even bottom. The soundings disclose no deep holes, or channels, and no rock is found except in the vicinity of Chancy Bay. The lake has no tides, but its surface is quickly ruffled by the winds, and it is not uncommon to find the water at least 30 decimeters (1 foot) higher on one side than on the other, due wholly to the influence of the wind pressure. The water in the lake, when not agitated, is clean and wholesome, and is regarded by hunters and fishermen, who frequent the lake, as extremely healthful.* The lake had no well-defined outlet to the sea until within recent years, but during the rainy season, its waters overflowed its banks from the mouth of Fish-eating Creek on the west around the south side to a point on the east several miles north of Pelican Bay, a distance of probably 112 kilometers. With such a width of overflow, it matters not even now how hard it rains as the level of the lake cannot rise above a level of 6.8 meters (22.5 feet).

About 1884, a canal 21.3 meters (70 feet) wide and 1.8 meters (6 feet) deep was completed from the Caloosahatchee River at Ft. Thompson up through Lake Flirt, Bonnet Lake and Lake Hicpochee, making a direct and well-defined channel into Lake Okeechobee. Lying north and west of Lake Okeechobee is a watershed, seven and a half times as large as the lake. The drainage area is comparatively level, having a gentle slope from the north toward the south, and discharges all of its run-off into Lake Okeechobee. In the area are lakes, the largest of which are Tohopekaliga, Kissimmee and Istokpoga. During the rainy season, the rainfall not removed by evaporation is poured down Fish-eating Creek, the Kissimmee River, Taylor Creek and along the numerous sloughs and low depressions on the north into Lake Okeechobee.

"The watershed drained by Lake Okeechobee, including the area of the lake, is approximately 4,000,000 acres. There is no authentic record of the rainfall in this area except at Kissimmee in the northern portion, so we must assume that the rainfall at this station represents fairly accurately that of the entire watershed. The average annual rainfall at Kissimmee for the past nine

*Everglades of Florida, Senate Document No. 89, 131. 1911.

years is 53 inches, with a minimum of 40.22 inches in 1902 and a maximum of 70.92 inches in 1887. If this amount of rainfall was uniformly distributed throughout the year, it would not be a difficult matter to take care of it, but it is excessive during the summer and fall, often exceeding 12 inches in a single month. It is this period of heavy rain that must be considered in planning the drainage of this section. In the months of July and August, 1905, there was a total rainfall of 27.95 inches recorded at Kissimmee. During the same period, there was but 20 inches at Jupiter, 24 inches at Fort Myers, and 25 at Miami. This would seem to indicate that the rain at Kissimmee was increased by some local influence that did not exist throughout the peninsula, and that probably the rainfall over the entire drainage area did not exceed 26 inches. As a fall of 26 inches in any other two consecutive months is the closest approach to this amount, it is safe to conclude that 26 inches is an extraordinary rainfall, not likely to occur except at rare intervals, and it would hardly be wise or prudent to base the carrying capacity of the drains on this amount. Since a rainfall of 18 to 22 inches in two consecutive months has occurred three times during the last decade, we may reasonably expect the same amount in the future. In order to have a fair margin of safety in the storage capacity of Lake Okeechobee, canals should be provided having sufficient discharge to remove a maximum rainfall of 24 inches from the entire watershed in two consecutive months."

"From examination of the data available it appears that the amount of moisture removed by a mixed growth of vegetation, such as trees, bushes, and grass, is at least 0.10 inch per day. All the Okeechobee watershed, however, is covered with a thick growth of vegetation, there being numerous lakes and ponds and extensive areas of almost barren soil, but if this vegetation were concentrated on one-half of the area it would cover it quite densely; so, instead of estimating the water removed by the plant growth at 0.10 inch for the entire watershed, we will restrict it to one-half the area, as more nearly representing the conditions in southern Florida. Assuming 0.25 inch to be removed by free evaporation and 0.05 inch by plant growth, we have 0.30 inch per day, or a total of 9 inches per month taken up by these two methods. This is 75 per cent. of the mean rainfall for July and August, which amount agrees quite closely with the results obtained in other places where careful and continued experiments have been made. Since the maximum rainfall that is likely to occur in July and August is 24 inches, the mean daily precipitation for these

two months equals 24 divided by 62 equals 0.387 inch. The difference between this amount and 0.30 inch, the amount removed by evaporation, is 0.087 inch, which is the mean daily run-off from the entire watershed. This amount of run-off, although not obtained by actual measurements, is supported by the results of the most careful experiments that have been carried on in this country, Europe, and India."

The western and southern shores of Lake Okeechobee are shallow and grown up to partly submerged grasses and sedges, while north of the outlet canal into Lake Hicpochee, it is bordered by the true saw-grass vegetation of the Everglades, so that here its shore line is ill-defined in wet weather. The grasses, sedges and other shore plants grow out some distance in the shallow water along the shore. Occasional detached masses of such vegetation on sand flats form small submerged islands with the tops of the plants projecting above the surface of the water. South Bay is also pretty well filled with pondweed and lined with muddy shores.

Lake Shore Plant Association.—The sedgy shore of the southern end of the lake is characterized by the presence of the following plants collected by the writer on June 22, 1912: the maiden-cane, Panicum hemitomon Schult., which grows in close associations, Scirpus validus Vahl., Sagittaria lancifolia L., the floating pondweed, Potamogeton lucens L., the wampee, or pickerel weed, Pontederia cordata L., the bonnet, or spatterdock, Nymphæa (Nuphar) advena Soland, the lizard's tail, Saururus cernuus L., and water-pennywort, Hydrocotyle umbellata L.

Back of the shore line in the soil more or less disturbed by cultivation is a weedy strip about 6–20 meters wide, in which is found a mixture of native and introduced plants that grow as weeds. The most remarkable plant of the list is the so-called careless weed, Acnida australis A. Gray, which grows to a height of 4.5 meters (15 feet) and with a stem diameter of over 3 decimeters. Several other weeds grow with almost equal rankness. This weedy strip continues along the banks of the canal, piled with dredged material on which for some miles south of the lake the weeds grow until the muck of the Everglades becomes so loose and watery that the material dredged out of the canals gradually sinks out of sight. Under such conditions, the canal bank is formed by the flat surface of the Everglades and its exclusive saw-grass vegetation, and here the weeds are not found.

PLANTS OF THE WEEDY STRIP OF THE LAKE OKEECHOBEE SHORE

Panicum dichotomiflorum Michx.
Chaetochloa magna (Griseb.) Scribn.
Cyperus ferax Vahl.
Cyperus surinamensis Rottb.
Salix longipes Anders.
Boehmeria cylindrica (L.) Willd.
Acnida cuspidata Bert.
Hibiscus grandiflorus Michx.
Kosteletzkya altheaeifolia (Chapm.) A. Gray.
Carica papaya L.
Jussiaea peruviana L.
Calonyction (Ipomoea) aculeatum (L.) House.
Verbena polystachya H. B. K.
Eupatorium capillifolium (Lam.) Small.
Eupatorium serotinum Michx.
Pluchea purpurascens (Sw.) DC.
Sonchus oleraceus L.

CUSTARD-APPLE FORMATION

This is one of the most remarkable formations in South Florida (Plate X, Fig. 1). It consists of an almost pure growth of the custard-apple, Annona glabra L., with an occasional cypress tree sticking its top above the general level of the crowns of the custard-apple trees. As seen from the cupola of the hotel on the south shore of Lake Okeechobee at the entrance to the South New River Canal, the custard-apple forest extends east and west, as far as the eye could reach, and in a southward direction from the border of the lake, a distance of about 4.8 kilometers (3 miles). Over the tops of the trees in that direction the apparently illimitable expanses of the saw-grass in the Everglades beyond stretched to the horizon in the far distance. The width of the formation is in a few places only half a mile and along the south shore of the lake it is separated from the water by a narrow strip of shore line. The location of the extended custard-apple forest, or hammock, is shown on the large map extending on the west from the Three Mile Canal around the southern end of the lake to Pelican Bay and around the shores of Pelican Bay, where the remarkable pond-apple hammock serves as a rookery for various kinds of birds and is the home of the otter, raccoon and blind-mosquitoes. The last do not bite, but make life unbearable by their numbers and their vicious, persistent attacks which are pure bluff.* Behind the mud flats, which surround Torry Island and to some extent on Kreamer Island, are pond-apple (custard-apple) hammocks, the trees of which in dense growth have curiously buttressed and branched

* *Small, John K.:* Exploration in the Everglades and on the Florida Keys, Journ. N. Y. Bot. Gard., 15: 69–79, Apr., 1914.

trunks. Other vegetation is scant. Various lianes struggle to the tops of the trees to reach the sunlight and include a kind of gourd and a high-climbing dew-flower, Commelina, which with its stout fleshy stems and branches climbs over the limbs of the pond-apple trees, often reaching to the highest branches. The main forest of custard-apple trees south of the lake consists of a close stand of trees 9 meters (30 feet) tall, forming a dense shade, so that a twilight pervades these solitudes. The branches are twisted and interlocked and the crown is therefore very dense. The undergrowth is close, so that it is with difficulty that one can penetrate the forest (Plate X, Fig. 1). Three ferns are conspicuous on the ground. A rare fern, new to Florida, Meniscium serratum Cav., was collected by me, as also the large tropic fern, Acrostichum aureum L. and Dryopteris patens (Sw.) Kuntze. All of these ferns, in sporulation on June 22, were growing out of the rich, black humus covering the deep muck of the Everglades. This fact suggests the natural succession of vegetation, the custard-apple trees invading a saw-grass strip, so that the custard-apple forest is subsequent to a saw-grass marsh in the region under discussion. The southern elder, Sambucus intermedia Carr., in full flower on June 22 occupied the more open and therefore lighter parts of the forest. Two herbs, however, are noteworthy as growing in almost pure associations on the forest floor. In one place, we find Persicaria (Polygonum) punctata (Ell.) Small covering the ground, in other places Commelina erecta L. is exclusive. Two other herbs are important elements of the herbaceous contingent, viz., the false nettle, Boehmeria cylindrica (L.) Willd., and Jussiaea peruviana L., while the moon-flower, Calonyction (Ipomoea) aculeatum (L.) House, climbed up the trees, especially on the lake, or open, side of the forest where it covers every available support in dense hanging masses. Two epiphytes were dislodged from the tree branches with a pole. An epiphytic orchid in flower June 22, Epidendrum tampense Lindl. (=Encyclia tampense (Lindl.) Small, is common on the custard-apple trees, as is also the fern Polypodium polypodioides (L.) A. S. Hitchc. (=P. incanum Sw.) (Plate X, Fig. 1). It seems that the custard-apple, or pond-apple tree, is extremely sensitive to frosts, and its growth in a narrow strip along the south shore of Lake Okeechobee is to be explained by the ameliorating effect of the large, shallow body of water, which warms up rapidly in the sun, lying to the north and west of the southern shore line of the lake (see map).

A letter of query directed to Dr. W. E. Safford, who has monographed the

PLATE X

Custard-apple forest, south shore of Lake Okeechobee, June 22, 1912. Original.

FIG. 2.

Transverse marl prairie bordered on both sides by tall pine forest near Princeton, Fla. August 18, 1911. Original.

genus Annona, as to the means of distribution of the custard-apple, elicited the following information under date of Aug. 20, 1912:

"Dear Sir:—I have the honor to acknowledge the receipt of your recent letter in which you ask suggestions as to how the swamp-apple, Annona glabra, is dispersed. This is a question which has perplexed me. The associations of this plant are with species of so-called mangroves of wide distribution. This species itself occurs on both sides of tropical America, the Galapagos islands and the west coast of Africa. It would be interesting to find out whether detached branches take root readily in the mud. The wood is so light, it is called corkwood, and the roots are used for corks and floats for nets. An experiment might be made by breaking off limbs or roots, and after soaking them for a time in salt water plant them in mud. I cannot find that their fruits are any more buoyant than other Annonas. If it were birds that distributed the seeds, why would not the more attractive species be just as widely dispersed? The seeds may possibly be borne by currents. They say that the fruit is eaten by aquatic lizards, or iguanas of the Bahamas. I wonder if they are carried from island to island."

Large custard-apple trees are seen with enlarged bases, as if the influence of submergence in water induced their formation.

EVERGLADE FORMATION

The Everglades (Pah-hay[h]-o-kee = grassy water) is an immense grassy plain, covered in the wet season, June to November, with an average depth of 66 cm. (26 inches) of water, so that it is an extensive marsh stretching on all sides to the horizon line and relieved in some places by clumps of bushes, or low trees, and characterized by lagoons, channels, or slues of open water, or filled with various aquatic plants. Hence the meaning of the word Everglades—from *ever*, signifying *all*, or wholly grassy glade. They extend from the southern margin of Lake Okeechobee some 144.8 kilometers (90 miles) toward Cape Sable, the southwestern extremity of Florida, and vary in width from 48 to 80 kilometers (30 to 50 miles). Two arms of saw-grass vegetation extend northward on both sides of Lake Okeechobee, so that the lake is almost completely surrounded, as is clearly shown in the accompanying phytogeographic map. It consists of an area of 1,136,000 hectares (4,000 square miles, or about 2,560,000 acres) of marsh land. The normal surface of Lake

Okeechobee is 6.22 meters (20.42 feet) above the mean low water level of the Gulf of Mexico. From the center of the Everglades to Chokoloskee Bay and the waters of Ten Thousand Islands the distance is 86.8 kilometers (54 miles), making the fall 11.5 cm. (4.53 inches) to the mile.

Draining the Everglades are numerous rivers and streams, beginning at the lower end of St. Lucie Sound, on the Atlantic, and extending around the southern extremity of the peninsula to Charlotte Harbor on the Gulf, as follows: Halpatiokee, Jupiter, and Hillsboro Rivers, Ratones and Cypress Creeks, West Fork and South Fork of Middle River, New River, South Fork of New River, Snake Creek, Arch Creek, Little Arch Creek, Little River, Miami River, Chi's Cut, Albahatchee River, Shark River, Harney River, Fatsallehonetha River, Roger, Chittahatchee, Fatlathatchee, Alcatapachee and Lakpahatchee rivers, Wekiva Inlet, Gallivan, Falsewater, Malso, Corkscrew and Caloosahatchee rivers, and five small unnamed streams that empty into the Gulf of Mexico.

In all the streams flowing from the 'Glades on the eastern side are rapids, as the streams leave the big saw-grass marsh. From the rapidity of current and the number of these rivers, it is evident that they have their source not in a spring, but in a great reservoir. The topography of the land near the coast and its relation to the Everglades are interesting and important. The rise of the general surface from the coast line westward for a distance of 4.8 or 5.4 kilometers (3 to 4 miles) is 2.7 to 4.8 meters (6 to 9 feet). From this, westward across the Everglades, the rate is about 0.3 foot per mile. The dividing line between the slopes toward the Gulf and the Atlantic is about 6.68 meters (22 feet) above tide and extends south from near the center line of Lake Okeechobee. The rock rim on the east side of the 'Glades is from 1.5 to 2 meters (5 to 7 feet) higher than the surface of the marsh.

The following condensed statement represents the prominent characteristics of the country as given in the notes of Mr. Stewart and Mr. Brett:*

* Everglades of Florida, p. 158. 1911. The measurements are kept in feet and not given in meters or fractions.

ELEVATIONS SOUTHEASTERLY FROM FORT MYERS TO BROWN'S STORE

	Feet
Sea level at Fort Myers	0.0
General surface, 3 miles southeasterly	19.9
General surface, 12 miles southeasterly	27.7
General surface, 20 miles southeasterly	30.7
General surface, 25 miles southeasterly	25.0
General surface, at Immokalee	37.7
Water surface of Lake Trafford	20.0
High-water mark, Lake Trafford	22.0
General surface, 6 miles east of Immokalee	28.0
Water surface of Okaloacoochee Slough	25.3
Surface of land near Okaloacoochee Slough	27.0
Surface near Rock Lake	24.0
Water surface of lake	21.0
Surface, 8 miles southeasterly from Rock Lake	21.0
Surface, 4 miles west of Brown's store	17.7
Surface, 1 mile west of Brown's store	17.0
Extreme high-water mark of Everglades at Brown's store	16.3
General surface of muck at Brown's store	14.6

ELEVATIONS ACROSS THE EVERGLADES EAST FROM BROWN'S STORE

Surface of muck, 5 miles east of Brown's store	14.0
Surface of muck, 20 miles east of Brown's store	13.0
Surface of rock, 20 miles east of Brown's store	8.0
Surface of muck, 30 miles east of Brown's store	12.6
Surface of rock, 30 miles east of Brown's store	8.0
Surface of muck, 40 miles east of Brown's store	11.6
Surface of rock, 40 miles east of Brown's store	10.0
Ridge at Osceola's Camp	18.7
Surface, 4 miles west of Pompano	12.3
Surface, at Pompano	11.0
Low tide at Fort Lauderdale (one observation)	.6

Origin of Everglades.—The Everglades lie in what has been called a rock-rimmed basin, and a vast sink, but these expressions are probably inexact. It is true that bed rock lies at or near the surface toward the edges of the Everglades. Along the east side, from Jupiter River to Hillsboro River, the outcrops are few. South of New River they are more numerous, and from just north of Miami to Homestead, the rock forms bare areas with a maximum elevation of 4.5 meters (15 feet) above mean water level in the Everglades. This series of ridges bends at the southern end of the peninsula to the west forming the series of rocky Everglade keys, reaching nearly to White Water Bay. South of the limestone region from Cutler on Bay Biscayne around the southern end of the mainland past Cape Sable, White Water Bay, Ponce de Leon Bay and the Ten Thousand Islands, there are no outcrops of bedrock above sea level. On the southwestern side of the Everglades, rock

comes within 30 dm. (1 foot) of low water level in Rock Creek near Lostmans River. In short, outcrops of bed rock are found around the main part of the Everglades from Jupiter River to Ft. Shackleford, with no important interruption except between Lostmans River and the farthest west of the rocky keys beyond Long Key (Everglades). In this break, one of the natural drainage outlets of the Everglades, rock does not on the average lie more than 3 feet below the level of low water. Sanford* believes that the term sink is not accurate, because the area is too large; the rock floor too flat. He believes that the Everglades occupy a series of comparatively shallow rock hollows, the partial contour of which will be indicated when the soundings are given which indicate the depth of the muck.

The underlying rock is nearly horizontal, dipping slightly toward the south, but does not denote any sudden upheaval (Text Fig. 2). Its surface is irregular, being full of pot-holes, deep fissures, varied by irregular and jagged ridges and seams. It is not stratified, but is homogeneous in character and is rotten, porous and susceptible of being easily excavated. This rock foundation was at one time the bed of an inland sea, or ancient lake which has been filled in its southern part to form the present Everglades. The entire basin has been filled to the level of the marginal rims with a deposit of sand and muck, so that the surface of the Everglades is now a plane with a gentle slope from north to south. On the other hand, Sanford† suggests that the Everglades owe their existence primarily to an abundant rainfall and to the slight elevation of southern Florida. He thinks that even if there were no basin structure whatever and were the bed rock surface absolutely flat along an east-west line, the present rainfall, the sluggish drainage and the luxuriant growth of vegetation would result in a marsh forming in the center of the peninsula from Lake Okeechobee. In short, he thinks the Everglades resemble in origin the Dismal Swamp of North Carolina and Virginia.

Character of the Everglade Soil.—The peat found throughout the larger part of the Everglades rests on rock, sand, or marl. In places, soundings indicate more than one peat bed, with sand between (Text Fig. 2). The relations of peat and sand to the bed rock west of Ft. Lauderdale are shown in the accompanying generalized section along the drainage canal, based on data furnished by J. H. Newman, engineer (Text Fig. 2). The map of the Everglades

* *Sanford, Samuel:* Second Annual Report, Florida State Geological Survey, 1909: 192.

† *Sanford, Samuel:* Second Annual Report, Florida State Geological Survey, 1909: 193.

drainage district issued by the trustees of the internal improvement fund, November, 1911, gives the depths of the muck along the various canals and survey routes. Along the Miami Branch Canal from north to south, the depth* of the muck is 10, 4, 6.5, 5.5, 7, 6.5, 7, 3.8, 4, 6 feet. Along the North New River Canal, the determined muck depths are from Lake Okeechobee to the eastern edge of the Everglades 10, 2.5, 8, 7, 6.5, 5, 4, 3.5, 4.5, 7, 7, 6, 5 feet. The depths as measured along the West Palm Beach Canal in the extreme northeastern part of the Everglades region are 10, 8, 10, 3, 4 feet. The depths along an east-west line from Brown's store to the eastern rim of the Everglades are 2, 4, 3, 5, 4.5, 5, 2 feet. The depth of the muck along this line averages 4.5 feet (1.36 meters). The top soil is a turf composed largely of saw-grass roots, except in the leads and shallow basins, where the saw-grass does not grow. Here the vegeta-

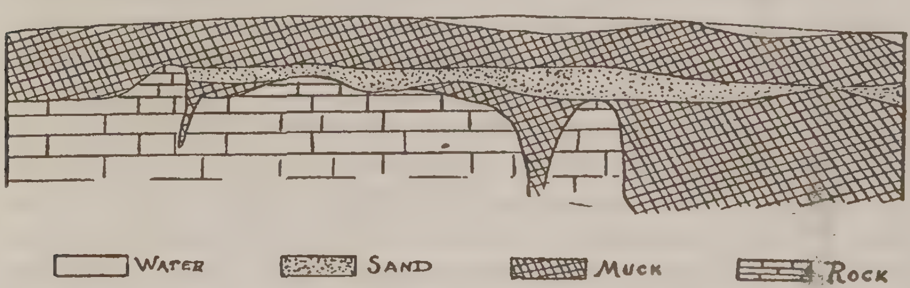

FIG. 2.
Section of Everglades west of Ft. Lauderdale, Fla., after Samuel Sanford, Second Annual Report, Florida Geological Survey, 1908–09: 193.

tion is more completely decayed and is so loose when saturated with water that one sinks to the bottom sand, or rock. The "leads," filled with water and water-lilies alternating with saw-grass, give a deceptive undulating appearance as one looks across the expanse, though, as will be noted, the slope is gradual. The islands scattered over the Glades form an insignificant part of the whole—probably less than one-half of one per cent. of the entire saw-grass marsh.

The people of South Florida speak of the "Upper" Glades and the "Lower" Glades, the former term being applied in general to the marsh between Lake Okeechobee and the north line of Township 51, and the latter to the territory south of that line. There is but little peat on the rock in the

* As the numbers are taken from the original map they are given unaltered without reduction to the metric system.

Lower Glades and the saw-grass is less dense than in the Upper Glades. The Upper Glades have the deeper muck and much the greater agricultural possibilities. The state dredges working near Ft. Lauderdale uncovered numerous salt-water shells in the sand at a depth of 4 meters (13 feet) below the surface. There are water trails through the Everglades used by the Seminole Indians, who frequently traverse them in their dug-out canoes during periods of high water. They rarely penetrate the saw-grass of the interior, but confine themselves principally to the islands and the timbered edges of the Glades and the water channels through which they make their way to the east coast when in need of supplies.

"The origin of the muck soil is, of course, vegetable matter.* There are no data for estimating the length of time required for the formation of these muck deposits. The whole of the Okeechobee muck lands is covered almost exclusively by saw grass. This is a cyperaceous plant of the genus Cladium. During the winter and early spring months this dense growth of grass often becomes dry enough to burn, and large areas are often burned over. The muck soils of Florida, as shown by a later analysis, are rich in nitrogen and lime, but are markedly deficient in such mineral constituents as potash and phosphoric acid. The presence, therefore, of so large a body of limestone, mingled with phosphatic pebbles, is a matter of no mean importance when the agricultural future of these lands is considered. A few of these pebbles were picked up at the headwaters of the Caloosahatchee and examined for phosphoric acid. The mean percentage of phosphoric acid found was 0.697. This region has not been prospected at all for phosphate deposits, but it would not be surprising if they were discovered to exist here in great abundance, as they are found from 60 to 100 miles farther west, in the Peace River region."

"The question of the subsidence of these soils under cultivation is also one of considerable importance. If the organic matter which they contain should decay there would, of course, be a marked depression in the level of the soil. The oldest portions of the muck land in cultivation have now been tilled for about eight years. In these lands where sugar cane was planted it has been found that there has been a subsidence of several inches, so that the stubble of the sugar cane has been left protruding to this distance above the surface. This depression, however, seems to have occurred chiefly in the first two or three years of the cultivation, and there seems to have been no such marked

* Everglades of Florida (Senate Document No. 89), pages 76, 117.

lowering in the surface of the soil since that time. It is not likely, therefore, that the soil will ever again be sufficiently depressed to bring it under the level of the water, although it must be confessed that the period of observation has been entirely too short to make any definite prophecy in regard to the future. The organic matter, however, of the muck lands does not seem to be subject to complete decomposition by the natural processes of decay. The humic bodies, consisting largely of carbon, appear to be capable of resisting partially, if not altogether, the oxidation to which they are exposed by cultivation. There is considerable danger, however, from fire, especially during the dry season. When fires are once started with dry muck, they continue to burn until the lands are flooded on the accession of the rainy season."

Several samples of muck were collected by Mr. Brett and his party while running the level line across the Everglades in February and March, 1907.

MUCK SOILS FROM THE INTERIOR OF THE EVERGLADES

	Soil No. 8.[1]	Soil No. 11.[2]
	Per cent.	*Per cent.*
Lime	2.25	2.21
Potash	.15	.08
Phosphoric acid	.19	.19
Nitrogen	3.16	2.58

[1] Taken 8 miles west of Pompano.
[2] Taken 18 miles west of Pompano.

Climate of the Everglades.—The following tables, compiled from the records of the United States Weather Bureau, give the mean annual temperature and the highest and lowest temperatures at Jupiter and Ft. Myers for a period of nine years:

MEAN ANNUAL, HIGHEST, AND LOWEST TEMPERATURES AT JUPITER AND FT. MYERS, 1898–1906

Years.	Jupiter.			Ft. Myers.		
	Annual Mean Temperature.	Highest during the Year.	Lowest during the Year.	Annual Mean Temperature.	Highest during the Year.	Lowest during the Year.
	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*
1898	73.7	91	31	72.6	94	28
1899	74.4	93	28	73.1	93	28
1900	74.3	93	31	72.3	92	34
1901	72.6	92	38	70.3	94	32
1902	74.4	96	38	72.2	94	31
1903	74.1	96	36	71.8	94	35
1904	73.8	94	39	...	94	34
1905	74.6	94	24	73.5	94	27
1906	73.7	91	30	72.4	92	31

TOTAL RAINFALL, NUMBER OF DAYS OF RAINFALL, AND THE MAXIMUM RAINFALL IN 24 HOURS, FOR EACH MONTH OF THE YEARS 1898 TO 1906, INCLUSIVE *

KISSIMMEE, OSCEOLA COUNTY, FLA.

Months.	1898			1899			1900			1901			1902		
	Total rainfall.	Number of days of rainfall.	Maximum rainfall in 24 hours.	Total rainfall.	Number of days of rainfall.	Maximum rainfall in 24 hours.	Total rainfall.	Number of days of rainfall.	Maximum rainfall in 24 hours.	Total rainfall.	Number of days of rainfall.	Maximum rainfall in 24 hours.	Total rainfall.	Number of days of rainfall.	Maximum rainfall in 24 hours.
January	0.23	1	0.23	5.72	9	1.11	4.22	8	1.16	0.92	3	0.55	0.19	1	0.19
February	1.12	3	.42	11.53	7	4.75	2.65	5	.91	2.46	5	.94	6.07	6	2.65
March	..	..	..	1.68	4	.91	6.07	6	1.91	3.51	6	.80	1.88	4	1.17
April	.12	1	.12	3.06	4	1.64	3.02	6	1.05	3.23	3	2.91	1.73	4	1.00
May	.35	1	.35	1.60	1	1.60	5.84	7	3.00	2.96	3	2.30	.34	2	.23
June	5.75	6	1.50	3.06	7	.87	8.18	15	1.40	8.78	12	1.66	5.85	7	3.30
July	7.90	10	2.25	8.37	15	2.59	5.66	14	1.23	2.84	10	.58	5.36	12	2.10
August	11.41	15	2.20	11.06	15	2.05	3.23	4	1.48	9.91	19	1.35	7.27	9	2.39
September	4.52	10	1.47	7.03	10	2.68	4.50	7	1.96	12.95	11	4.60	6.35	15	1.35
October	5.17	13	1.43	15.98	7	9.50	4.83	8	2.67	1.18	3	.57	3.07	8	.76
November	.88	4	.25	.23	1	.23	1.62	3	1.00	.67	2	.52	1.15	3	.87
December	3.02	9	1.45	1.60	4	.94	5.09	6	3.25	1.35	3	.80	.96	2	.66
	40.47	..	..	70.92	..	..	54.91	..	..	50.76	..	..	40.22	.	..

Months.	1903			1904			1905			1906		
	Total rainfall.	Number of days of rainfall.	Maximum rainfall in 24 hours.	Total rainfall.	Number of days of rainfall.	Maximum rainfall in 24 hours.	Total rainfall.	Number of days of rainfall.	Maximum rainfall in 24 hours.	Total rainfall.	Number of days of rainfall.	Maximum rainfall in 24 hours.
January	4.76	8	1.66	4.16	8	1.40	0.70	2	0.62	6.43	6	3.34
February	5.04	6	2.71	5.16	5	2.12	.91	4	.67	1.49	4	.56
March	5.84	10	2.00	.80	3	.60	3.88	8	1.25	2.74	7	.93
April	.25	1	.25	2.25	4	.85	1.82	6	.60	1.48	4	.68
May	6.68	9	2.35	.51	4	.25	7.17	12	2.05	6.77	11	2.24
June	10.12	14	1.45	8.19	14	1.50	4.46	11	2 25	10.21	15	1.70
July	6.07	13	1.58	8.56	9	2.55	14.05	22	2.10	6.65	14	2.10
August	4.31	8	1.10	4.53	9	1.20	13.90	23	2.70	2.59	6	.82
September	12.06	14	2.95	4.66	10	1.30	4.94	9	1.50	3.26	8	.84
October	1.02	5	.31	6.72	12	1.55	3.19	5	1.40	2.00	6	.66
November	3.56	5	2.30	3.15	5	1.73	Trace	..	Trace	.16	1	.16
December	1.51	3	1.09	.80	2	.70	9.43	15	3.20	.04	2	.02
	61.22	..	..	49.49	..	..	64.45	..	..	43.82	..	..

* Everglades of Florida (Senate Document No. 89).

The stations at Ft. Myers and at Jupiter are both north of the main body of the Everglades, and no doubt show from 2° to 4° lower temperature than would be registered in the center of the 'Glades. The minimum temperature here is higher than that of the sugar district in Louisiana south of New Orleans, where cane is seldom injured by frost.

The two preceding tables give the records of the rainfall at Kissimmee, in the northern part of the water-shed, and at Jupiter, on the east coast opposite Lake Okeechobee, for a period of nine years, and represent fairly well the rainfall that may be anticipated in the Everglades:

The average annual rainfall of the Everglades portion of the State is about 63 inches (160 cm.). The so-called dry season, or portion of the year in which there is the least rainfall, occurs between the months of November and March, during which time the normal precipitation is about 11.5 inches (29 cm.), ranging from 1.5 to 2.5 inches (4–7 cm.) per month. During this season portions of the prairie lands are planted to vegetables, principally tomatoes, which are more profitable for shipping to the northern market, and when properly fertilized produce large crops. The remainder of the year these lands are frequently covered with water and are largely abandoned until the opening of the winter season, when they are again plowed and planted.

Vegetation of the Everglades (Plate VII, Fig. 2; Plate VIII, Fig. 1).—The Everglades is a vast saw-grass marsh, or perhaps we may call it a wet prairie, extending in unbroken formation in all directions to the horizon, or sky line, as out at sea. The Everglades, the location of which is shown on the map, is a sea of the sedge, or saw-grass, which is the dominant plant over an immense area. It will be noted that the Everglades vegetation almost completely surrounds Lake Okeechobee. It sends a long extension northwestward back of West Palm Beach through the Loxahatchee Marsh to join Jupiter River, which finds its way to the Atlantic Ocean through Jupiter Inlet. The Glades back of West Palm Beach are thus connected with one of the principal drainage channels leading from the central part of the Everglades. On the south, the Everglades blend with the coastal prairie, and in the southwest, they almost reach the Gulf of Mexico. A deep embayment of the Everglades along their western border is found projecting westward, so as to join the area of lowland covered by the Big Cypress Swamp, and another extension projects, so as to include Lake Hicpochee. Upon the muck rests a sheet of water

(Text Fig. 2). The depth varies with the conformation of the bottom. The whole area is covered with a rank growth of a coarse sedge, 2 to 3 meters (8 or 10 feet) high, having leaves with a fine, serrated edge like a saw, hence the common name (Plate VII, Fig. 2). The saw-grass, Cladium effusum (Sw.) Torr. (=Mariscus jamaicensis (Crantz) Britton), arises from a root-stock with matted roots. In many portions of the Everglades, the saw-grass is so thick as to be almost impenetrable; but it is intersected by tortuous channels terminating at short or long distances in apparently impenetrable barriers of grass. The surface is rapidly changed with rain, the difference of level being from 6 decimeters to 1 meter (2 to 3 feet). E. W. Chadwick, who as a surveyor crossed the Everglades before the canals were dug, in a letter to the writer dated March 22, 1911, mentioned a wide, dry ridge in the center of the Glades. He mentioned the saw-grass ridges alternating with open leads of water running approximately in a southeastern direction. Such are probably the ridges described by Willoughby (Across the Everglades, page 110), who states that when the rock is near the surface with little soil, the saw-grass grows to a height of about 1.2 meters (4 feet), but where the soil is deeper and wetter, it reaches a height of 3 meters (10 feet). Similar ridges are noted in the writer's description of a transsection of the Everglades along the North New River Canal.

The vegetation of the Everglades was studied by the writer on four different trips into them. One visit was made out from West Palm Beach, two by ascending the Miami River, and a fourth by crossing the entire region from Lake Okeechobee, a distance of 100 kilometers (62 miles), by the North New River Canal to Ft. Lauderdale. The botanic results of these trips are given herewith. Back of West Palm Beach the saw-grass marsh connects with the Loxahatchee Marsh, which is an integral part of the Everglades. The saw-grass marshes here alternate with lake vegetation about Lake Clear with cypress bays, prairies, and pineland. The prevailing plant is the saw-grass, scattered through which are a few isolated palmettos, Sabal palmetto (Walt.) R. & S. The open lagoons of water (Plate VIII, Fig. 1) were characterized by the water-lily, Castalia odorata (Dryand.) Woodr., associated with Sagittaria lancifolia L., pickerel-weed, Pontederia cordata L., and pond-weed, Potamogeton sp. The water-lilies, pickerel-weed, etc., usually grew in pure associations with little intermixture of other species and their distribution

depended upon the depth of the water and on other factors. Sometimes these associations fronted a cypress bay (Plate VIII, Fig. 1) with waxberry, Cerothamnus (Myrica) ceriferus (L.) Small, with the cypress trees draped with Spanish-moss. The cat-tail, Typha, was in evidence in pure association. The plants collected by me on August 10, 1911, most of them in full flower, in the 6-mile tramp across these marshes, were Cyperus speciosus Vahl., Dichromena colorata (L.) A. Hitchc., Eriocaulon decangulare L., Gyrotheca tinctoria (Walt.) Salisb., Polygala cruciata L., P. lutea L., P. ramosa Ell., Hibiscus furcellatus Lam., Kosteletzkya virginica (L.) A. Gray, Ascyrum tetrapetalum (Lam.) Vail, Hypericum aspalathoides Willd., Triadenum virginianum (L.) Raf., Ludwigia alata Ell., a tall umbellifer, Oxypolis filiformis (Walt.) Britton, Sabbatia grandiflora (A. Gray) Small, Nama corymbosum (Ell.) Kuntze, Hyptis radiata Willd., Eupatorium recurvans Small, Pluchea foetida (L.) B. S. P., P. imbricata (Kearney) Nash. The showy plants were those of the genera Hibiscus, Kosteletzkya, Sabbatia and Nama. A species of bladderwort, Utricularia, was common, and a fern, Blechnum serrulatum Rich., grew at the edges of the cypress heads. The herbs enumerated above were not gathered in one association, but were scattered here and there through the saw-grass, the leaves of which were blackened in spots by an epiphytic, parasitic fungus, Meliola sp. The climbing hempweed, perhaps Mikania batatifolia DC., was found growing over the saw-grass clumps. After this glade is crossed, a pure forest of the slash-pine, Pinus caribaea Morelet, stretches for a distance of 6 to 9 kilometers (4 to 6 miles) to the eastern edge of the Everglades proper.

In the Everglades west of the headwaters of the Miami River exist clumps of low shrubs, such as the buttonbush, Cephalanthus occidentalis L., and Baccharis glomeruliflora Pers., with which enters into association the royal-fern, Osmunda regalis L. The plants of the Everglades associated with the saw-grass, which grows here 2 meters (6 feet) tall, are more or less scattered, and one in walking through the saw-grass finds here one, then another. A conspicuous plant growing as tall as the saw-grass, is Eupatorium capillifolium (Lam.) Small, while Mikania batatifolia DC., as a vine, ascends any available plant. Outside of these few, we find the following species as elements of the Everglade vegetation:

*Sagittaria lancifolia L.
Andropogon glomeratus (Walt.) B. S. P.
Chaetochloa magna (Griseb.) Scribn.
Manisuris rugosa (Nutt.) Kuntze.
Spartina junciformis Engelm. & Gray.
Rhynchospora corniculata (Lam.) A. Gray.
*Crinum americanum L.
*Saururus cernuus L.
Boehmeria cylindrica (L.) Willd.
Boehmeria scabra (Porter) Small.
Persicaria hydropiperoides (Michx.) Small.
Kosteletzkya virginica (L.) A. Gray.
Ludwigia alata Ell.
Phyla nodiflora (L.) Greene.
Hydrotrida caroliniana (Walt.) Small (=Herpestis amplexicaulis Pursh.).
Diodia virginiana L.
Eupatorium serotinum Michx.
Pluchea foetida (L.) B. S. P.

Occasionally a part of the Everglades extends into the pineland as a long, narrow, finger-like extension, where the level is sufficiently beneath the pineland to collect the drainage water of the surrounding pine forest. Such a glade was visited 3 kilometers west of Miami on December 27, 1910, and the following species were collected in the area controlled by saw-grass, Cladium effusum (Sw.) Torr. (=Mariscus jamaicense (Crantz) Britt. Along its edges were the ferns Acrostichum aureum L., Blechnum serrulatum L. C. Rich., and the royal-fern, Osmunda regalis L. Associated with the saw-grass were other grass-like plants, grasses and sedges, viz., Andropogon glomeratus (Walt.) B. S. P., Dichromena colorata (L.) A. Hitchc., Rhynchospora divergens M. A. Curtis. In the wetter soil between the clumps of saw-grass were gathered Sagittaria lancifolia L. and spider-lilies, Crinum americanum L., while such herbs as Agalinis linifolia (Nutt.) Britton (=Gerardia linifolia Nutt.), tall Eupatorium capillifolium (Lam.) Small, and Flaveria linearis Lag. were scattered about in the grass. Two vines were collected, Ampelopsis arborea (L.) Rusby (=Cissus bipinnata (Michx.) Nutt.), and the climbing Mikania batatifolia DC. Where the Everglades proper touches the chain of Everglade keys at Long Key, Small collected the following plants, not noted before: Eleocharis cellulosa Torr., Habenella Garberi (Porter) Small, and Ibidium (Gyrostachys) tortile (Sw.) House.

The section across the Everglades made by boat along the North New River Canal from Lake Okeechobee to the eastern edge of the Everglades at the headwaters of New River will be presented in extracts from field note-books in which are recorded observations made en route. As the entire dis-

* Common.

tance is marked by mile posts erected along the banks of the canal, the exact location of the different plant associations is thus made possible. L. O. painted on each of the sign boards refers to Lake Okeechobee; Ft. L., to Ft. Lauderdale. The birds and other animals noted are given for the general interest attached to such observations. Extensive notes were also made on the map of the Everglade drainage district of Florida issued by the trustees of the internal improvement fund, Nov., 1911.

Phytogeographic Section Across the Everglades.—The Lake Okeechobee entrance to the North New River Canal is 98 kilometers (61 miles) from Ft. Lauderdale. The first 5 to 6 kilometers (3 or 4 miles) of the canal is cut through the custard-apple forest with its trees loaded with epiphytes. The material dredged from the canal, and which forms its banks, has since the canal was dug been covered with various weeds, some of which we have noted on a previous page. The weeds are twined with dense masses of the moon-flower, Calonyction (Ipomoea) aculeatum (L.) House, while in the canal the writer noted Sagittaria lancifolia L., some water-hyacinths, Piaropus crassipes (Mart.) Britton, and cat-tails, Typha. The water-turkey was noted, which can swim almost wholly submerged, and the great blue-heron flew out of the saw-grass. After passing the custard-apple formation, previously described, we find that it is fronted on the south by a willow strip which runs out into the Everglades. Before us we see the illimitable stretches of the saw-grass.

L. O. 6 Miles, L. O. 7 Miles–L. O. 12 Miles.—We passed unbroken saw-grass with no hammocks. In June the Everglades in color resemble a large field of grain just turning from its green, unripe condition to the brownish-yellow ripe condition. Gifford compares the Everglades to a vast pancake sliced in the middle by the canal.* Before us, as far as the eye can reach, is a level prairie-like expanse of saw-grass. The red-wing blackbird was seen and we startled a few buzzards feeding on alligator carcasses from which the hides had been removed by hunters.

L. O. 13 Miles.—The unbroken saw-grass continues. A transverse ditch has been dug at every mile post through the dredged material, so as to drain the water from the Glades into the canal.

L. O. 14–L. O. 19 Miles.—The landscape and the vegetation remain unchanged.

* *Gifford, John:* The Everglade Magazine, Oct., 1912.

L. O. 20 Miles.—A low tree hammock was noted about 3 kilometers (2 miles) to the east of the canal.

L. O. 21 Miles.—The launch passed unbroken saw-grass, sweeping to the distant horizon. The embankments have been so recently formed that there has not been time for the establishment of weeds. The edge of the canal is fringed with saw-grass, Sagittaria lancifolia L., Piaropus crassipes (Mart.) Britton, and Pontederia cordata L.

L. O. 23 Miles.—The white water-lily, Castalia odorata (Dryand.) Woodr. & Wood, was noted in the canal.

L. O. 23–L. O. 24 Miles.—De Soto Tiger, a noted Seminole, was killed here by a renegade white man on Dec. 28, 1911. Natural vegetation grows on both banks of the canal. Large white-crane was noted where we transferred to the launch Frances. A large blue-heron was seen.

L. O. 26 Miles.—Here the saw-grass vegetation is dominant without hammocks and with the water in the canal and on the glade land at the same level.

L. O. 27 Miles.—The saw-grass forms the exclusive growth with no hammocks. A large slue, or channel, was filled with the white water-lily, Castalia odorata Woodr. & Wood, also Crinum americanum L., Pontederia cordata L. and Sagittaria lancifolia L. Here the native plants are not admixed with any introduced weeds, which are absent.

L. O. 28 Miles.—The portion of the Glades north of this point may be termed Upper Glades, because the vast saw-grass marsh is unbroken either by hammocks or channels. Before the canals were cut the Indians never penetrated the Upper Glades on account of the absence of open water and the density of the saw-grass. A small willow hammock was passed to the right, close to the canal. The low trees were loaded with epiphytes.

L. O. 29 Miles.—The channels become more frequent and they are filled in part with water-lilies, spider-lilies, pickerel-weed and other aquatic plants, as also the lagoons surrounded by unbroken saw-grass.

L. O. 30 Miles.—The saw-grass is everywhere.

L. O. 31 Miles.—About half way, Nymphæa advena macrophylla (Small) Miller & Standley, the spatterdock, was seen in a slue here. A tree hammock was seen about one-half mile away from the canal with a channel leading toward it. The banks were covered with loose limestone rock brought up from the bottom of the canal by the suction dredge.

L. O. 32 Miles.—The saw-grass is everywhere. The presence of dredged rock here indicates the removal of a ridge of that material.

L. O. 33 Miles.—Very little dredged rock lines the banks of the canal, hence the muck is deeper and formed in a deep depression. A clump of bushes was passed close to the canal on the right.

L. O. 34 Miles.—Long lines of dredged rock indicate the section of another ridge. The slues become more frequent at the first bend of the canal. A clump of buttonbush, Cephalanthus occidentalis L., was noted.

L. O. 35 Miles to L. O. 36 Miles.—Saw-grass prevails. An eagle was seen.

L. O. 37 Miles (*Ft. L. 24 Miles*).—A slue was passed with saw-grass dominant. A low clump of trees was noted to the right of the canal.

L. O. 39 Miles (*Ft. L. 22 Miles*).—Here was very low, wet saw-grass with lagoons and channel filled with water in which grew Nymphaea advena Soland. An occasional clump of bushes was noteworthy and a large hammock of low trees about a mile to the eastward. A great blue-heron was seen.

L. O. 40 Miles (*Ft. L. 21 Miles*).—A large bald-eagle flew from the low, wet saw-grass marsh. A large amount of dredged rock material was piled high on both sides of the canal, indicating an Everglade ridge. Small clumps of trees were passed before the elbow of the canal was reached. Here two shrubs were common, viz., Cerothamnus (Myrica) ceriferus (L.) Small and Cephalanthus occidentalis L.

L. O. 41 Miles (*Ft. L. 20 Miles*).—The saw-grass is everywhere with intersecting slues. Passed a clump of low trees on the left bank of the canal below the bend. A low ridge was found on the right side covered with clumps of bushes.

L. O. 43 Miles (*Ft. L. 18 Miles*).—Here the saw-grass is broken by true hammocks, which become more frequent as we proceed southeastward until the sky-line seems to be a continuous line of low trees. Here are lagoons with yellow spatterdock. A hammock with several large trees was noted about half a mile away to the left.

It may be stated at this point before we continue the field notes that the Lower Glades are characterized by frequent channels, lagoons and islands. The only map of the Everglades which shows these islands is the Military Map of the Peninsula of Florida, south of Tampa Bay, compiled from the Latest and Most Reliable Authorities by Lieut. J. C. Ives, and published in April, 1856. East of the 30th meridian are given from north to south, Saunders,

Pine, Sam Jones, Council, Encampment, and other islands, while between the 30th and 31st meridian are noted Prophets, Cabbage, Alligator, Chokikas, Jakiki islands. These islands have been placed as hammockland on the phytogeographic map. This map of Lieut. Ives also shows the routes of Major Childs, Colonel Harney, Captains Wright and Dawson across the Everglades. Some of these islands were sighted by the writer on his trip across the Everglades, but of them only one was identified with certainty, namely, Pine Island. The following early account will give some idea of the character of these islands:* "Many of the islands are but little above the level of the water; but some of them are from 2 to 3 feet high, with a soil as rich as any that can be formed. Others are more sandy. The principal timber on most of the rich islands is live-oak, wild-fig, papaya, and cabbage-palmetto, thickly festooned with a great variety of vines. All the islands are surrounded with dense grass circles, from 100 to 500 yards wide. Boats can only approach the outward edge of this circle. The Indians cultivate the inside of the islands only, leaving a border of live-oak and wild-fig, which are very ornamental trees. The wild-fig is, by the Spaniards, called havi. It is a little fig about the size of a kernel of corn—a perfect fig in miniature. In their fields they plant corn, pumpkins, tobacco, squashes, melons, and lima beans in abundance. Cocoanuts, plantains, bananas, and sweet potatoes are found on some of the islands. It is very probable that coffee would grow here, as frost never reaches these islands. Chitto-tus-te-nug-gee, or Snake-warrior, * * * took possession of an island about 20 miles west of Little River; had procured to be cleared about 20 acres of first-rate land; built upon it two small towns, and drew to it, from Sam Jones's men, near 60 inhabitants. About 3 miles west of Chittos Island is situated Tuscones. It is inhabited by an Indian family, who have erected a few houses and cultivated some small fields of corn and cane. The island cultivated and usually inhabited by Sam Jones is about 20 miles west of Tuscones. It is about half a mile long, but not quite so wide. It had three villages and as many hunting grounds. Attached to this are many smaller islands, all cultivated for provisions, but no houses. Narrow channels of water separate them from each other. The old chief is said to have here 70 warriors, many of them with families. Most of these islands swarm with fleas, cockroaches, and mosquitoes. A great many

* Senate Document No. 89 (1911), Everglades of Florida, p. 64, Extract from Manuscript of John Lee Williams, Esq.

islands were found near there highly cultivated; but it is not probable that one-tenth part of the islands have ever been visited by the whites. On the southern route from the Miami River, and about 40 miles from that stream, there is a beautiful island called Hocomothlacco. Around this island there is a circle of grass, or mud, 400 yards wide. It is highly cultivated with provisions. Seven miles north and northwest of this lies Efanoc-co-qu-chee. This is not cultivated, but has some cleared land on it. It is used as a kind of caravansary or stopping place for boats on their route across the Big Cypress. Six miles northwest is Co-chok-o-ne-ha-jo. This island is cleared and cultivated. It is near the center of the Glades. Six miles farther is In-tas-kee, a large island inhabited and richly cultivated. From this island the current passes to the east; after passing it the current sets to the south-west."

L. O. 45 Miles (Ft. L. 16 Miles).—A large island identified as Pine Island was seen at a distance. As the launch neared this island, the pine trees assumed their columnar form and serrated skyline. This island has some of the finest Everglades land and was set aside by the proclamation of President Taft as an Indian Reservation. Wet saw-grass marsh was everywhere, open channels and lagoons abound.

L. O. 46 Miles (Ft. L. 15 Miles).—The hammocks of large trees become more common. One consisted of custard-apple trees surrounded by saw-grass and aquatic vegetation. A big pile of dredged rock indicated the presence of a rock ridge running across the Everglades. A white-tailed hawk rose slowly.

L. O. 47 Miles (Ft. L. 14 Miles).—The same vegetation was passed.

L. O. 48 Miles (Ft. L. 13 Miles).—Saw-grass is present everywhere.

L. O. 49 Miles (Ft. L. 12 Miles).—The saw-grass vegetation is not continuous, but is broken by lagoons and low clumps of bushes, such as wax-berry, Cerothamnus ceriferus (L.) Small, and buttonbush, Cephalanthus occidentalis L.

L. O. 51 Miles (Ft. L. 10 Miles).—Many thickets are found here separated from each other by lagoons.

L. O. 52 Miles (Ft. L. 9 Miles).—Here the boat is abreast of Pine Island surrounded by saw-grass. The old embankments are covered with various plants. The eastern pine forest, stretching north and south, was first noted at this point on the canal.

L. O. 53 Miles (Ft. L. 8 Miles).—The high and sandy banks are covered with grasses. The saw-grass expanses are dotted over with hammocks.

L. O. 55 Miles (Ft. L. 6 Miles).—Here we reach the eastern edge of the Everglades where the cypress heads begin to be in evidence. The huge cypress trees grow in dense stands loaded with epiphytes. The red-maple, Acer rubrum L., was observed for the first time. Here is Sabal palmetto (Walt.) R. & S.

New River.—Here the cypress swamps blend with the river hammock vegetation, where the cypress is common together with custard-apple, Annona glabra L., red-maple, Acer rubrum L., cocoa-plum, Chrysobalanus icaco L., with such lianes as Smilax laurifolia L., bullace-grape, Muscadinia (Vitis) Munsoniana (Simps.) Small. The tall palmetto trees support two characteristic epiphytic ferns, Phlebodium aureum (L.) R. Br. and Vittaria lineata (L.) J. E. Smith.

It will be noted from the preceding account that the vegetation of this vast tract of fresh-water marsh, known as the Everglades, is fairly uniform over the whole region. The saw-grass is everywhere, the common and typic plant with an admixture of less prominent species, with the lagoons and channels filled with aquatic plants. Until canals were dug, it was a region of romance, crossed only by the picturesque Seminole Indians and inhabited by a few renegade white men, who have made travel through the unexplored portions of South Florida dangerous. It is a region of great distances and solitudes with bright suns, balmy air and clear unpolluted waters that are alive with fishes that reduce the mosquito nuisance to a minimum by feeding upon the mosquito larvae. Formerly thousands of alligators basked in the sun along the lagoons that mirror the surface of the sea of saw-grass, but they are infrequent now, only five having been seen by the writer in his boat trip from Ft. Myers to Ft. Lauderdale across the entire peninsula. The bird life is remarkable for the number of the large wading birds that frequent this vast marsh, formerly unmolested by man, and which now lazily fly upward as the explorer approaches them by boat. The stories of miasmatic vapors, of gloomy, malarious swamps are without foundation, as there is no more healthful region in North America. It has on account of its inaccessibility remained a terra incognita, but with the opening of the drainage canals, it will be visited every year by increasing numbers of people. Sample areas of the wild vegetation of the Everglades ought to be preserved and the interesting wild bird life carefully protected against ruthless destruction. It has been the land of the Seminole. It will be a land

of small plantations, if judiciously handled, and "a kingdom as full of people as hives are of bees," in the words of the first discoverer in writing to King Ferdinand of Spain.

The following list of plants was made from the sheets in the Herbarium of the New York Botanical Garden:

A PARTIAL LIST OF EVERGLADE PLANTS

Tripsacum floridanum Porter.
Andropogon tenuispatheus Nash.
Coelorachis (Manisuris) rugosa (Nutt.) Nash.
Paspalum giganteum Baldw.
Paspalum solitarium Nash.
Valota insularis (L.) Chapm.
Syntherisma marginatum (Link) Nash.
Panicum agrostoides Muhl.
Panicum coerulescens Hack.
Panicum condensum Nash.
Panicum ciliiferum Nash.
Panicum neuranthum Griseb.
Panicum polycaulon Nash.
Steinchisma hians (Ell.) Nash.
Chaetochloa imberbis (Poir) Scribn.
Chaetochloa magna (Griseb.) Scribn.
Muhlenbergia filipes M. A. Curtis.
Spartina junciformis Engelm. & Gray.
Phragmites phragmites (L.) Karst.
Eragrostis Elliottii S. Wats.
Cyperus alternifolius L.
Cyperus haspan L.
Cyperus paniculatus Rottb.
Cyperus Pollardi Britton.
Cyperus tetragonus Ell.
Fuirena breviseta Coville.
Fuirena scirpoidea Michx.
Eleocharis capitata (L.) R. Br.
Eleocharis cellulosa Torr.
Dichromena colorata (L.) A. Hitchc.
Rhynchospora caduca Ell.
Rhynchospora corniculata (Lam.) A. Gray.
Rhynchospora divergens M. A. Curtis.
Rhynchospora Tracyi Britton.
Scleria gracilis Ell.
Scleria verticillata Muhl.
Peltandra virginica (L.) Kunth.
Eriocaulon compressum Lam.
Eriocaulon decangulare L.
Eriocaulon Ravenelii Chapm.
Pontederia cordata L.
Juncus megacephalus M. A. Curtis.
Aletris bracteata Northrop.
Aletris lutea Small.
Crinum americanum L.
Hymenocallis occidentalis Kunth.
Ibidium cernuum (L.) House.
Limodorum Simpsonii Small.
Platypus altus (L.) Small.
Nymphaea advena macrophylla (Small) Miller & Standley.
Magnolia virginiana L.
Chrysobalanus pellocarpus Mey.
Ascyrum tetrapetalum (Lam.) Vail.
Hypericum opacum T. & G.
Tamala (Persea) pubescens (Pursh.) Small.
Oxypolis filiformis (Walt.) Britton.
Acerates floridana (Lam.) A. Hitchc.
Buchnera elongata Sw.
Cephalanthus occidentalis L.
Lobelia glandulosa Walt.
Lobelia paludosa Nutt.
Pluchea foetida (L.) B. S. P.
Coreopsis gladiata Walt.
Coreopsis Leavenworthii T. & G.
Mesadenia lanceolata (Nutt.) Raf.

FRESHWATER MARSH FORMATION

There seems to be in popular usage no apparent difference between a marsh and a swamp, and the definitions of the two words in our dictionaries of the English language have confused their essential significance. Harper* has

* *Harper, Roland M.:* Some Neglected Aspects of the Campaign Against Swamps. Southern Woodlands 2: 46–67, Aug., 1908; Ann. N. Y. Acad. Sci. 17: 25, 1906.

attempted to define the difference and his classification of swamps is the best that has been made, yet he has not clearly emphasized how the two terms should be used to make them exact, as ecologic terms descriptive of vegetation. It seems to the writer that the word swamp should be used for an area covered by trees, or shrubs, and with a wet soil wholly or partially submerged with water during the greater part of the year. According to this definition, we have salt-water swamps (mangrove swamps) and freshwater swamps (tree swamp, bush swamp, cedar swamp and cypress swamp). The word marsh should be used for treeless, wet places in which sphagnum is not influential, hence we have salt marsh and freshwater marsh, exclusive of bogs in which sphagnum plays an important rôle.

Helophytic Formations	Swamps (Wet Areas with Trees, or Bushes).	Salt	Mangrove Swamp.
		Fresh	Cedar Swamp.
			River Swamp.
			Cypress Swamp, etc.
	Marshes (Wet Treeless Areas).	Salt	Salt Marsh.
		Fresh	Everglades.
			River.
			Sloughs, etc.

With this distinction in view, the discussion which follows will deal with the marshes, other than the Everglades, which according to our definition above would be included in the category of marshes.

River Marsh Formation.—Along the rivers in South Florida, outside of the river hammocks and growing along the shallow shores, we find a large number of helophytes. Some of them are rooted, others are true aquatic plants, and yet, both morphologic forms must be considered as belonging to the marsh formation, because they are inseparably connected with each other in the association. They contribute to the formation of the marsh muck and they are concerned with the various phases of the successions.

Along the banks of the Miami River (Plate VI, Fig. 1) the marsh is well developed as a distinct formation. In some parts of the stream, the arrow-leaf, Sagittaria lancifolia L., forms pure associations (Sagittaria Association). The saw-grass, Cladium effusum (Sw.) Torr. (=Mariscus jamaicense (Crantz) Britton), in an embayment of the river shore, forms an exclusive growth (Cla-

dium Association), as does the cat-tail, Typha angustifolia L., which alternates as a pure association with areas of mangroves. The pickerel-weed, Pontederia cordata L., is also found in pure groups (Pontederia Association in Plate VI, Fig. 1), and so is the spatterdock, Nymphaea (Nuphar) advena macrophylla (Small) Miller & Standley (Nymphaea Association). The reed-grass, Phragmites, is found in exclusive growth and is conspicuous in some places. One of the most striking associations was that formed of a large, floating bladderwort, Utricularia oligosperma St. Hil., found at the junction of the North and South forks of the Miami River. The submerged associations of aquatic plants, which clog the ordinary propellers of power boats, are characterized by the pure growth and the prevalence of Vallisneria americana Michx., Naias flexilis (Willd.) Rostk., and brittlewort, Chara sp. Again the associations may be formed by an admixture of these prominent marsh species. Sometimes one, two, or even three or four, are found associated (Plate VI, Fig. 1); so that we have many combinations of these plants along the Miami River banks. Several species are rarely found in pure association, but they enter as elements of the other associations—such plants as the fern, Acrostichum aureum L., sedge, Dichromena colorata (L.) A. S. Hitchc., spider-lily, Crinum americanum L., Nymphoides (Limnanthemum) aquaticum (Nutt.) Kuntze, and Nama corymbosum (Ell.) Kuntze, the last in the wet sand at the stream's edge. The woody plants at the inner edge of the marsh have been described among river hammock plants (Plate VI, Fig. 1).

The marsh plants of Hancock Creek, a tributary of the Caloosahatchee River, opposite Ft. Myers, are:

Sacciolepsis striata (Lam.) Nash.
Scirpus validus Vahl.
Piaropus (Pontederia) crassipes (Mart.) Britt.
Crinum americanum L.
Ceratophyllum demersum L.
Kosteletzkya althaeifolia (Chapm.) A. Gray.
Hydrocotyle umbellata L.

Several other large marshes, not so large as the Everglades, but of sufficient size to merit recognition on the map drawn to a scale of $\frac{1}{500.000}$, are Halpatiokee Marsh, north of Jupiter River, the Loxahatchee Marsh, which is continuous with the Everglades and drains into Jupiter River, the Tlalhlopopkahatchee Marsh at the head-waters of Fisheating Creek and the Okaloacoochee Marsh,

or Slough, north of the Big Cypress region in southwest Florida. No ecologic survey has been made of these freshwater marshes, but they merit mention as areas of large size characterized by helophytes. In a letter from I. C. Foster of Ft. Myers, Fla., dated September 30, 1913, is given some interesting information about the Okaloacoochee Slough. "I have just seen Dr. J. E. Brecht in reference to the Okaloacoochee Slough. He says that there are no trees in the slough proper. There are cypress heads, now and then, bordering on it, but it is just a saw-grass slough. There are only two places in its whole length from Ft. Thompson to the south end of it where you can cross, because it is so soft and boggy. It drains by a series of smaller sloughs, or cypress heads into Chokoloskee Bay on the Gulf. I should think, from the doctor's description, it does not resemble the Everglades as much as an ordinary marsh. There is no river draining it into the Gulf, but it is drained as above described."

Allapatah Flats.—East of Lake Okeechobee, the fringe or strip of the Everglades back of the cypress swamps on the lake shore fades away irregularly in the Allapatah Flats, a region largely under water at the end of each rainy season, where are interwinding strips of saw-grass marsh, cypress heads, and more rarely a hammock on a slight rise in the almost dead level of the surface.

PRAIRIE FORMATIONS

Ecologically speaking, a prairie in the sense in which it is used in Florida is not the same as a western prairie. The only point that they have in common is that they are flat, treeless, grass-covered areas. The Florida prairies merge with the open pine savannas on the one hand and with the open hammock-dotted savannas on the other. The typically wet prairies merge with the Everglades, and other marsh formations, which touch them. As in all ecologic work, the student must recognize that there are no hard and fast lines of distinction, but all conditions of intergradation exist.

The sedge and wire-grass prairies are most extensive north and west of Lake Okeechobee, often extending for 32 to 48 kilometers (20 or 30 miles), unbroken except by a few scattering pines, but in which occur frequent beds of saw-palmetto. These prairies have a smooth surface, are apparently perfectly level, and during the rainy season are covered many inches deep with water. The soil is usually a white sand with occasional spots of loam. There are prairies of the same kind scattered throughout the woods on the east side of

Lake Okeechobee. Some attempts have been made to cultivate some of them, but owing to the lack of drainage the crops have been destroyed during the wet season and most of the projects undertaken have been abandoned.

The largest typic prairie is one situated north of the Caloosahatchee River, west of the Everglades along the west shore of Lake Okeechobee and west of Peace Creek. It is bisected in an east and west direction by Fisheating Creek. The prairie itself touches the Caloosahatchee River near Citrus Center, which is situated in its midst, and where the writer has seen it (Plate VII, Fig. 1).

Physiognomically, it resembles a prairie-grass formation, where the principal species are sod formers, so that the typic appearance of such prairies is an extended surface covered with turf. The prairie surface, however, is marked in some places, as near Citrus Center, by palmetto hammocks usually of circumscribed area (Plate VII, Fig. 1). Where this prairie touches on the Everglades, it blends insensibly with saw-grass vegetation, as is seen on approaching Lake Hicpochee. Where the pine woods touch this prairie, the pine trees in scattered phalanx advance on to the prairie surface, which may be compared then to a pine savanna. Another large prairie occupies the country along the western edge of the Everglades and the Okaloacoochee Slough. Brown's Store is situated in the southern part of this semicircular prairie.

Along the east coast of Florida, below Miami, the pineland is characterized by narrow prairies, the names of which from north to south are Peter Prairie, Cauldwell Prairie, Gosmann Prairie, Sterritt Prairie (Map and Text Figure 1), Long Prairie and Big Hammock Prairie. The long direction of these prairies is approximately at right angles to the eastern edge of the Everglades and the Atlantic coast. They represent probably ancient drainage, or spillways, of the Everglades, and their soil is wet, saturated, or submerged with water by torrential rains. Physiognomically, such prairies (Plate X, Fig. 2) resemble the Everglades, and Small* considers them identical with the vast saw-grass marsh to the west, but on account of their geographic location and for other points of difference, I have included them with the prairies. In the first place, the soil of these transverse prairies is a white, calcareous marl, and if it consists largely of shells, it is known as shell marl, while that of the Upper Everglades is a black muck rich in vegetal matter. Another difference is that through

* Small believes these distinctions do not exist. He points out that the same plants and the same soil are common to the prairies and to the distant parts of the Everglades, and that with the muck soil of the Everglades, there are areas of sand and of marl too. My authority for the above distinctions was J. C. Baile of Miami, an old settler, who had cultivated the soils under discussion.

natural drainage the prairie surface is dry during certain seasons of the year and firm enough for the pedestrian to walk dry shod over it. Advantage is taken of this dry period by the settlers to raise an extensive acreage of tomatoes. One of the prairies at Larkin was characterized by a tough, wiry grass quite different in appearance from the Everglade vegetation associated with pickerel-weed, Pontederia cordata L. The second and third prairie were filled with saw-grass and showed the presence of Sagittaria lancifolia L. The fourth prairie was characterized by a clump of willows in its middle portion. Below Benson, a fifth prairie was filled with saw-grass, arrow-leaf, Sagittaria lancifolia L., and Crinum americanum L. At Rockdale, the same type of vegetation was noted in the transverse prairie with a similar one at Modello. A few additional prairie plants are:

Eleocharis cellulosa Torr. Long Prairie, in flower, Oct. 31, 1906.

Ibidium (Gyrostachys) tortilis (Sw.) House. West of Cutler, Dade Co., in flower, March 23, 1904.

Limodorum Simpsonii Small. Gosman Prairie, Dade Co., in flower, March 24, 1904.

Coastal Prairie.—Along the shores of Biscayne Bay and the Bay of Florida, inside of the mangrove swamps, which fringe them part of the way, is a flat prairie, so slightly elevated above the sea that it is in part inundated with salt water in times of hurricanes and when the tides are exceptionally high. This prairie touches the pineland on the west and stretches as far north as Cutler, where the pineland approaches salt water (Map and Text Figure 1). The writer has crossed this prairie south of Homestead by train four times between the mainland and the Florida Keys and he has investigated its flora at close range in the neighborhood of Detroit. Physiognomically, it resembles the Everglades.* It is a vast saw-grass marsh in wet weather, or plain with open lagoons of water and intersected by numerous drainage channels. The tension line between the extreme southern pineland and the Great Coastal Prairie is not drawn sharply. The two formations sometimes blend imperceptibly. A few clumps of saw-palmetto, Serenoa serrulata (Michx.) Hook., grow out into the prairie and some of the prairie grasses enter the edge of

* Small believes that the distinction between the Everglades back of the Everglade keys and the "Front Prairie" east and south of the Everglade keys is fictitious. He has walked over the "Front Prairie" from Cutler south and west to Monroe County with the exception of about 3 miles, and did not find a single plant species that he did not find on the other side of the pineland. There are large areas not influenced by salt water and where mangroves are not in sight, according to Small.

the pine forest. At another place beyond Detroit, a hammock touches the open prairie with its sclerophyllous vegetation (Text Figure 1). The prairie is dotted with islands of bushes and low trees and Small considers it to be a part of the Everglades. There are differences, however, which lead one to consider the coastal prairie a distinct phytogeographic formation. The coastal prairie is influenced by salt water. Several miles south of the pineland, the surface of the prairie is sprinkled with low mangrove bushes, Rhizophora mangle L., raised on stilt-like roots and with round-headed tops of light-green foliage, and the presence of this tree phytogeographically makes the coastal prairie a formation distinct from the Everglades proper (Plate II, Fig. 1).

As the botanist approaches the coast of the Bay of Florida, where the railroad leaves the mainland for the Florida keys, the red-mangrove trees become larger and more closely set together until when the shore is reached they form a continuous fringe along the coast. From the tests made of Miami River water with the hydrometer in the midst of the mangrove vegetation, it would appear that the red-mangrove will grow in fresh water, hence it is not fresh water that reduces its size in the coastal prairie. Here it is surrounded with the saw-grass and other grasses that form a close sod or compact root system, the mangrove is finally suppressed, when the prairie vegetation becomes absolutely dominant. It would appear that with the advance of the southern coast of Florida by the encroachment of the mangroves upon the shallow bays the prairie vegetation follows the advance of the mangroves in natural succession, and as rapidly as the prairie conditions prevail the mangrove trees become reduced in size and finally are suppressed.* Some of the hammocks scattered over the prairie have such component species as tall palmettos, Sabal palmetto (Walt.) R. & S., waxberry, Cerothamnus (Myrica) ceriferus (L.) Small. At the southern end of the prairie, the surface is intersected by channels of water and the prairie islands are replaced by mangrove-covered islands.

The plants collected by the writer on the coastal prairie at Detroit are scattered over the surface and are not found in pure association. It is by this commingling of species that the surface soil is covered by a dense mass of the following plants:

* Harper suggests that the succession may be in the other direction, viz., the invasion of the prairie by mangrove trees.

Andropogon tenuispatheus Nash.
Eustachys petraea (Sw.) Desv.
Panicum virgatum L.
Cyperus speciosus Vahl.
Rhynchospora corniculata (Lam.) A. Gray.
Rhynchospora perplexa Britt.
Kosteletzkya virginica (L.) A. Gray.
Ludwigia microcarpa Michx.
Centella repanda (Pers.) Small.
Sabbatia grandiflora (A. Gray) Small.
Ipomoea speciosa Walt.
Asclepias lanceolata Walt.
Hyptis radiata Willd.
Diodia virginiana L.
Melothria pendula L.
Eupatorium mikanoides Chapm.
Mikania batatifolia DC.
Solidago angustifolia Ell.
Pluchea foetida (L.) B. S. P.

A small coastal prairie below Miami on the road to Cocoanut Grove and just north of that place is filled with coarse grasses and sedges and periodically flooded, when the salt water reaches it in very high tides. The alternation of the different formations at this point shows the control of edaphic conditions· The coast prairies occupy the marl soil, the pineland and the saw-palmetto, the drier rough oölitic limestone and the hammock is developed in a soil rich in organic matter.

With the description of the prairie formations, the synecologic study of the vegetation of South Florida comes to an end. The remainder of this monograph will deal with special problems connected with the study of the vegetation as a whole, and not under the caption of any particular formation. The following pages are devoted in part to a floristic analysis and in part to a statistic enumeration.

FLORISTIC ANALYSIS

Enumeration of Families, Genera, and Species.—The Miami Flora* includes 146 families, 522 genera and 878 species of seed-plants. Of these, there are 73 introduced genera and 82 introduced species. Twelve additional genera, which include introduced species, are not considered because they include native species. The Flora of the Florida Keys† includes 119 families, 408 genera and 627 species of seed-plants; of these 83 genera include 94 species of introduced plants. The explanation of the fact that the flora of the Florida keys is poorer than the Miami flora, is found in a number of contributing causes, one of which is the absence of freshwater streams, another the generally drier

* *Small, John K.:* Flora of Miami, New York, 1913.
† *Small, John K.:* Flora of the Florida Keys, New York, 1913.

condition of the soil. The physiography of the islands is less diversified than that of the mainland of peninsular Florida. The difference in the number of species in favor of the Miami region is 251 species and in genera 114. If we compare* the families of seed-plants in the Miami flora with those given in the last edition of Gray's Manual (Robinson and Fernald, 1908), we discover that the following families are represented in the Miami flora and not in Gray's Manual: Cycadaceae, Cymodoceaceae, Arecaceae, Alpiniaceae, Cannaceae, Marantaceae, Casuarinaceae, Petiveraceae, Batidaceae, Allionaceae, Malpighiaceae, Surianaceae, Burseraceae, Meliaceae, Dodonaeaceae, Buettneriaceae, Turneraceae, Papayaceae, Cassythaceae, Punicaceae, Terminaliaceae, Myrtaceae, Rhizophoraceae, Theophrastaceae, Ardisiaceae, Dichondraceae, Ehretiaceae, Avicenniaceae, Olacaceae, and Brunnoniaceae. The following families of flowering plants represented in the region covered by the new Gray's Manual are absent from the Miami district: Dioscoreaceae, Betulaceae, Calycanthaceae, Sarraceniaceae, Saxifragaceae, Hamamelidaceae, Platanaceae, Empetraceae, Violaceae, Araliaceae, Diapensiaceae, Valerianaceae, and others not of great importance. Sedges of the genus Carex are entirely absent in the Miami region. When we compare the Miami flora with that of the Florida keys by the same author and, therefore, strictly comparable as to the family limits, we discover that in passing from the mainland to the islands a number of families drop out. Such are Juniperaceae, Naiadaceae, Scheuchzeriaceae, Araceae, Juncaceae, Liliaceae, Haemodoraceae, Alpiniaceae, Cannaceae, Marantaceae, Burmanniaceae, Saururaceae, Piperaceae, Salicaceae, Fagaceae, Alsinaceae, Caryophyllaceae, Ranunculaceae, Magnoliaceae, Nympheaceae, Droseraceae, Aquifoliaceae, Cistaceae, Ericaceae, Vacciniaceae, Menyanthaceae, Polemoniaceae, Campanulaceae and Lobeliaceae, 29 families in all. Our surmise as to the absence of freshwater conditions on the Florida keys is corroborated by the absence of plants of the families Naiadaceae, Scheuchzeriaceae, Nympheaceae, Droseraceae and Menyanthaceae. We discover also in the flora of the Florida keys the absence of oaks, huckleberries, ranunculaceous plants, magnolias, buttonbushes (Cephalanthus), elders (Sambucus) and species of the genera Carex and Scirpus. There is only one golden-rod (Solidago) and three asters on the Florida keys.

* The comparison cannot be made exactly, because of the different views of the authors on the matter of family limits. However, the comparison is made as accurately as consistent with the different interpretations of family names and limits.

A number of families not included in the Miami flora are found in the manual of the Florida keys, viz., Hippocrateaceae, Canellaceae and Clusiaceae. The families that would not be represented in the Miami flora but for the fact that they are families of introduced plants are Convallariaceae, Musaceae, Alpiniaceae, Casuarinaceae, Basellaceae, Caryophyllaceae, Papaveraceae, Sedaceae, Papayaceae, Punicaceae and Plantaginaceae. The introduced families correspond exactly in the two regions of South Florida. That the flora of both the Miami region and that of the Florida keys is a chopped-up one is shown by the fact that there are 52 families out of 146 in the Miami flora with only one genus and one species, according to Small's interpretation of family limits. But for the presence of this one species, about one-third of the families would be absent entirely. In the Flora of the Florida Keys, 38 families have but one genus and one species. If we include those families of one genus and two species in each such genus, the number in the Miami flora is augmented by 8 families and in that of the Florida keys by 6 families. The big families of the Miami flora are in the order of their importance.

Family	Number of Genera	Number of Species
1. Poaceae	37	93
2. Carduaceae	43	82
3. Fabaceae	29	52
4. Euphorbiaceae	21	49
5. Cyperaceae	13	48
6. Orchidaceae	28	38
7. Rubiaceae	18	23
8. Rhinanthaceae	14	20
9. Malvaceae	10	19
10. Convolvulaceae	10	19
11. Solanaceae	5	14
12. Bromeliaceae	5	13
13. Verbenaceae	8	12
14. Cassiaceae	5	11
15. Asclepiadaceae	8	10
16. Leucojaceae	5	10
17. Amaranthaceae	9	9
18. Pinguiculaceae	7	9
19. Lamiaceae	8	8
20. Mimosaceae	7	8
21. Apocynaceae	6	7
22. Arecaceae	5	6
23. Acanthaceae	5	6
24. Allionaceae	5	6
	271	572

If we take the three families Fabaceae, Cassiaceae and Mimosaceae, which together represent the old family Leguminosae, the number of genera and

species representing the family Leguminosae would be respectively 41 genera and 71 species. In these 24 families, including over 5 species of plants in each family, are included 572 species out of a total flora of 878 species, or over one-half of the whole number of species.

Generic Coefficient.—The proportion of genera to species in a flora is known as the generic coefficient. The generic coefficient of the whole Miami flora is obtained as follows:

878 : 522 :: 100 : x, where x becomes 59.4%. The generic coefficient of the flora of the Florida keys is obtained likewise by the proportion:

627 : 408 :: 100 : x, where x = 65%.

If we exclude from the total number of genera and species the introduced ones, our total numbers stand for the Miami flora 796 species and 460 genera, and for the flora of the Florida keys 533 species and 346 genera. The generic coefficients would then stand for the Miami flora as 58.5% and for the flora of the Florida keys 64.9%, approximately in both estimations 59% and 65%. If we arrange this information in a table, we have:

Region	Species	Genera	Generic Coefficient
Miami	796	466	59%
Florida Keys	533	346	65%
N. J. Pine Barrens	555	250	45%
Altamaha Grit Region of Georgia [*]	797	404	50%
Southeastern United States	6364	1494	23%
Region of Gray's Manual	3413	821	24%
Central Rocky Mountains	2733	649	24%
British Flora (Druce) including aliens	2964	734	24%
Switzerland	2453	659	27%

The figures of this table are a direct confirmation of Jaccard's law [†] of plant distribution that "the Generic Coefficient is inversely proportional to the diversity of the ecologic conditions." Such regions as the central and northeastern United States (Gray's Manual); southeastern United States (Small's Flora); Rocky Mountains (Nelson's Manual); British Islands (Druce) and Switzerland have ecologic conditions of the greatest diversity, and hence low generic coefficients, while the Miami region, that of the Florida keys and the pine-barren region of New Jersey with fairly uniform physical character have relatively high generic coefficients.

Coefficient of Community.—Some emphasis has been placed by European

[*] See *Harper, R. M.:* Ann. N. Y. Acad. Sci. 17: 323.

[†] *Jaccard, Paul:* Nouvelles Recherches sur la Distribution Florale. Bull. Soc. Vaud. des Sci Nat., xliv: 259, 1908.

phytogeographers* upon the coefficient of community. The ratio of the number of species common to two districts to the total number of species in the two districts taken together is their coefficient of community. This is derived as follows:

$$\text{Coefficient of Community} = \frac{\text{Number of species common to 2 districts}}{\text{Total number of species in the 2 districts}} \times 100$$

Adding then the total number of species in the Flora of Miami (878) and the total number in the Flora of the Florida Keys (627), we have as the denominator, 1505, the total number of species in the two districts. The total number of species common to the Miami region and the Florida keys is 282, as obtained from Small's Flora of Miami. Hence, we have $\frac{282}{1505} \times 100 = 18.73\ \%$.

The coefficient of community for the two districts in South Florida is 18.73 per cent. Thus in spite of their proximity and the somewhat similar ecologic conditions, the flora of our two districts possess very different compositions.

ECOLOGIC ANALYSIS

Growth Forms.—In the classification of growth forms, I have chosen the system of Raunkiær,† because, in spite of its one-sidedness it emphasizes one of the most important features of plant life, and because it is easier to handle than other classifications of growth forms, and it is possible to express statistic data in comparison with other regions. The biologic types (growth forms) of Raunkiær are arranged according to the way in which plants live through the unfavorable seasons of the year, and emphasis is put upon the degree and the kind of protection afforded to the dormant buds. In countries where the conditions are favorable, the dominant plants are phanerophytes (Ph.), their buds being found on aërial branches. This group includes trees and shrubs. According to the height of the phanerophytes, Raunkiær divides them into mega-, meso-, mikro-, and nanophanerophytes. The chamæphytes (Ch.) are those plants with dormant buds on the surface of the ground, or just above it. In the former case, they are plants with superficial, creeping and persistent shoots; in the latter case, they are cushion-plants, or undershrubs. The hemicryptophytes (H.) have dormant buds found in the upper soil layer, just below the surface, while their aërial shoots are not perennial. The fourth

* *Jaccard, Paul:* The Distribution of the Flora in the Alpine Zone. The new Phytologist, xi: 39, Feb., 1912.

† *Raunkiær, C.:* Types biologiques pour la geographie botanique. Bull. Ac. Roy Sc. Danemark, 1905; Statistik der Lebensformen als Grundlage für die biologische Pflanzengeographie. Beitr. Bot. Centralbl., 27 (1910): 171–206d.

group is composed of cryptophytes characterized by their dormant buds being subterranean, or sub-aquatic. They include aquatic and marsh plants (helophytes), denoted by HH., and geophytes, denoted by G. The therophytes (Th.) are annual plants that live in the unfavorable season as seeds. Finally there are the stem succulents (S.) and the epiphytes (E.).

An attempt has been made to group the native species of the Miami region, the Florida keys and the pine-barren region of New Jersey under the above growth forms, but this has been no easy task, because our knowledge of the underground parts of many species is incomplete. It is, therefore, probable that mistakes have been made. Some of these mistakes will neutralize each other, but other errors are unavoidable when the descriptions and herbarium sheets do not enable the student to reach determinative conclusions. The percentages of the different growth forms in a region arranged in a series, or gamut, gives a picture, or spectrum, in the words of Raunkiær: "Ich werde deshalb der Kürzes halben im folgenden eine solche statistich-biologische Uebersicht als Spektrum bezeichnen, als biologisches Spektrum oder Pflanzenklimaspektrum." He has worked out theoretically a normal spectrum, which is given in the adjoined table. With this normal spectrum, other spectra can be compared. Under Ph. for St. Thomas and St. John islands, for the Seychelles, Aden and the Normal Spectrum, the percentages are arranged as MM., M. and N., i. e., megaphanerophytes, microphanerophytes and nanophanerophytes. It will be noticed, that in the Miami flora the hemicryptophytes are the most abundant, followed by the phanerophytes, the therophytes and the chamæphytes. In the flora of the Florida Keys, the phanerophytes preponderate, followed by the chamæphytes (20%), therophytes (20%) and the hemicryptophytes.

Plant Spectra Regions	Number of Species	Percentage of Species of Each Growth-form							
		S.	E.	Ph.	Ch.	H.	G.	HH.	Th.
Miami Region	793	.25	3	22	16	28	6	6	18
Florida Keys	527	1	2	32	20	19	3	3	20
N. J. Pine Barrens	458	.21	—	14	10	38	3	24	11
St. Thomas and St. John	904	2	1	5, 23, 30	12	9	3	1	14
Seychelles	258	1	3	10, 23, 24	6	12	3	2	16
Aden	176	1	—	—, 7, 26	27	19	3	—	17
Transcaspian Lowlands*	768	—	—	11	7	27	9	5	41
Pamir*	514	—	—	1	12	63	5	5	14
Death Valley	294	3	—	23	7	18	2	5	42
Samos	400	—	—	9	13	32	11	2	33
Libyan Desert	194	—	—	12	21	20	4	1	42
Cyrenaica	375	—	—	9	14	19	8	—	50
Normal Spectrum	400	1	3	6, 17, 20	9	27	3	1	13

* Paulsen, Ove: Studies on the Vegetation of the Transcaspian Lowlands, 1912: 135–173.

The actual number of species belonging to each growth form in the two Florida districts is:

Region	S.	E.	Ph.	Ch.	H.	G.	HH.	Th.
Miami	2	23	178	128	221	48	48	145
Florida Keys	6	11	168	104	99	17	15	108

The total number of phanerophytes in the Miami flora exceeds the total number on the Florida keys by ten, but as percentages of the total growth forms, the phanerophytes in the flora of the Florida keys are preponderant. If we contrast these percentages with those of the growth forms of the pine-barren region of New Jersey, we discover that the phanerophytes of that region form 14.1 per cent., and the chamæphytes 10 per cent., while the hemicryptophytes form 38 per cent. of the whole number of growth forms enumerated. Physiognomically, the phanerophytes are dominant in the pine-barren region of New Jersey, and they form the most striking part of the vegetation, while in South Florida the undergrowth beneath the dominant trees belonging to the phanerophytic and chamæphytic groups, while specifically more numerous, is from the standpoint of actual numbers less in evidence and of secondary importance. One specimen of a single species counts as much in fixing its standing in the determination of the percentages of growth forms as 100,000 individuals of a species count. We have, therefore, this fact brought into prominence that the growth forms of a region may be present in greater percentages of specific forms, but yet numerically, as to the actual number of individuals of those types, of relatively little importance. In the pine-barren region of New Jersey, we have a less number of species of phanerophytes (66) than in the Miami region (178) and the Florida keys (168), but yet, numerically, there are more phanerophytic individuals than in the two districts at the southern end of the Florida peninsula. While Raunkiær's spectra give valuable information as to the percentages of growth forms, they do not give any idea of the physiognomy of the vegetation, which must be expressed in other ways. As an approximation to this estimate, we use the descriptive terms of relative abundance: dominant, subdominant, abundant, occasional, rare, very rare, local, locally abundant, local but occasional.*

* For the significance of these terms consult *Tansley, A. G.:* An Ecological Study of a Cambridgeshire Woodland. Journal Linnæan Society, Botany, xl: 339–384, Jan., 1912.

The phanerophytic climate is characteristic of all tropic lands with a rainfall which is not so small that the vegetation is exposed to critical conditions on account of its absence. Examining our table, we find that in the large percentage of phanerophytes, the region of tropic Florida belongs in part at least to a phanerophytic climate, but it is not typic, as the percentages of hemicryptophytes, therophytes and chamæphytes are also large and in that respect the two regions of South Florida approach more closely the normal spectrum of Raunkiær.

EVOLUTION OF PLANT FORMATIONS

The history of the vegetation of South Florida may be traced best by beginning with the period of elevation when the Miami-Key West oölite was raised to its present level as an area of dry land. The limestone composing the Miami-Key West deposits soon weathered into a thin superficial soil which was early tenanted by the slash-pine, Pinus caribaea Morelet. The early occupancy of the oölite is evidenced by the fact that the slash-pine vegetation is found on some of the Lower keys, beginning with No Name Key and Little Pine Key and extending westward for a distance of 48 kilometers (30 miles) under similar edaphic conditions on the Miami-Key West oölitic limestone of which these islands consist. The presence of such slash-pine vegetation on these keys isolated by a considerable distance from the mainland oölite is evidence that these two widely separated areas of limestone were elevated at the same time and later were invaded by slash-pine vegetation which has remained in undisputed possession of the oölitic limestone deposits. The Upper keys, consisting of Key Largo limestone, were elevated subsequently, and at a time when hammock vegetation invaded the region, so that to-day hammocks are typic of the Key Largo limestone except the flat borders of such keys where the mangrove swamps are in evidence. This differential elevation of the two kinds of limestone indicates that hammock vegetation followed the pine vegetation in the occupancy of the Florida keys, and on the peninsular-mainland the same succession has probably been the course of events. Detached islands of slash-pine forest probably existed at the same time on the higher ground of southwest Florida, as far north as the Caloosahatchee River. The high land north of the Caloosahatchee River connected with the mainland farther north was elevated earlier than the Miami-Key West oölite, and at the

end of this elevation, it was invaded by the long-leaf pine forest, which already covered the northern central part of the state. Therefore, in all probability, the slash-pine forest is of southeastern origin, the long-leaf pine forest of northern. The first occupied the Lower keys and Miami region of the mainland, invading the higher newly elevated ground in southwestern Florida. The second forest merely extended itself southward, as rapidly as the land was elevated. Along the Caloosahatchee River, therefore, we find an interdigitation of the forests of the two trees as previously emphasized.

The immediate coast line of the peninsula with sandy deposits in the form of beach sand and dune sand was occupied by beach and thicket plants, while mangrove swamps covered the lower levels and assisted materially in the advancement of the coast line. The ancient dunes of the east coast had their genesis in the sand blown inland from the coast. It buried the ancient slash-pine forest, as is evidenced by the flat pineland, lakes, and marshes, which exist between the dunes at the old level. These inland sand dunes were covered by the rosemary scrub type of vegetation, where Pinus clausa (Engelm.) Vasey, Ceratiola ericoides Michx., and associated species are prevalent. An ancient lake of which the present Lake Okeechobee is a dwindled portion covered the basin now occupied by Lake Okeechobee and the surrounding Everglades. This ancient lake was bordered by prairies and cypress swamps, the present location of which is determined by following the shore line of that ancient lake. With the exception of the cypress heads along the main rivers of the region, all the large bodies of cypress in South Florida at the present time follow approximately the ancient limits of the older and greater lake. As the waters in the southern end of the ancient Lake Okeechobee were shallow, they were gradually converted by the growth of the saw-grass and other plants into the vast marsh, now designated as the Everglades. With the formation of the Everglades, the plant formations of South Florida reached much their present condition, position, and floristic character. Arranging the formations in the order of their probable appearance in South Florida, we have:

Beach and Dune Formations.
Mangrove Swamp Formation.
Long-leaf Pine Formation (west coast).
Slash-Pine Formation (east coast and Lower keys).
Hammock Formation.
River Bank Formation.

Cypress Swamp Formation.

Prairie Formation.

Everglade Formation.

Rosemary Formation.

Custard-Apple Formation.

At present, there is slight displacement taking place, although most of the types are exclusive. The pine forest is being invaded by hammock vegetation. The Everglades is being entered by broad-leaved shrubs and trees, which are found as islands, or hammocks, scattered here and there in the saw-grass marsh. The mangrove swamps are advancing seaward and are filling the shallow bays with islands of trees. A depression of the country would inaugurate changes, which would destroy the pine forest, beach vegetation, hammocks, cypress swamps and mangrove swamps. An elevation would destroy the Everglades, and would encourage the pine forest, the rosemary scrub and the hammock vegetation.

The attempt has been made in the foregoing to describe the vegetation of the region. Edaphic conditions are more important than climatic in an area of this size. All disturbing climatic factors can be eliminated from consideration and we are left to determine scientifically the influence of the important soils on the plant formations of the region. The thanks of the author are extended to friends, who have helped in the preparation of this monograph.

Everglades-grasshopper (Rhomalea microptera).

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